PERCEPTIONS ABOUT STUDENT DIVERSITY AND EQUITY IN EARLY CHILDHOOD SCIENCE EDUCATION: A TEACHER PREPARATION STUDY

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Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

May 2018

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Lee, Eun Young. *Perceptions about Student Diversity and Equity in Early Childhood Science Education: A Teacher Preparation Study*. Doctor of Philosophy (Curriculum and Instruction), May 2018, 123 pp., 20 tables, 3 figures, references, 246 titles.

Using a mixed-methods approach, the current study examined the relationship between early childhood preservice teachers' cultural awareness and their self-efficacy in equitable science education. It further aimed to determine if the relationship between these two constructs was moderated by their race/ethnicity or the number of languages they speak. Finally, it sought to identify preservice teachers' understanding of equity in science education, as well as how they planned to incorporate the equity concept into their future science teaching practices for diverse learners in early childhood classrooms. Data for this study were drawn from 380 preservice teachers who self-enrolled in a science methods course as part of a teacher preparation program. To measure the preservice teachers' cultural awareness and self-efficacy in equitable science education, two Likert-scale instruments, Cultural Diversity Awareness Inventory (CDAI) and Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST), were employed. Qualitative data were collected by administering 6 open-ended questions. For quantitative results, statistically significant findings indicated that when the participants were more aware of creating a multicultural environment and instruction and/or when they were less biased and were more sensitive/knowledgeable about diversity of students and families, their expectations about science learning of students from diverse backgrounds would be higher. Furthermore, when the participants were more aware of creating a multicultural environment and instruction and/or when they felt more comfortable about confronting students or parents whose cultures and languages were different from their own, they tended to have a stronger sense of efficacy in teaching science to those students. In addition, when the participants were less biased

and were also sensitive and knowledgeable about students' and families' diverse backgrounds, they were more likely to have a strong sense of science teaching efficacy. Along with these findings, participants' race/ethnicity was a statistically significant moderator affecting the relationship between their sense of science teaching outcome expectancy and awareness of creating a multicultural environment and instruction. When the awareness of creating a multicultural environment and instruction of both White and non-White participants were increased at an equal level, White participants' expectations for science learning of students from diverse backgrounds were higher than those of non-White participants. Measurement challenges were identified through the analysis process that compromised the validity of the quantitative findings. Thus, they should be interpreted with caution. For qualitative results, three predominant themes related to the participants' conceptualization of equity in science education were identified. First, the participants harbored alternative understandings of the definitions of equity in science education. One third of the participants understood equity as providing appropriate access and support based on the levels of students' needs whereas another one third defined equity as providing identical teaching services and resources to all students regardless of their backgrounds. They also conceptualized equity in science education as an issue independent of their future students' racial/ethnic backgrounds; instead, they regarded it as a subject associated with their students' English proficiency.

ACKNOWLEDGEMENTS

As completing this long doctoral journey, I first and foremost would like to give honor to my Lord for his guidance and protection from the beginning to the end. I look forward to his plan for my next chapter, and I hope to be used for his purpose. I am also thankful to all my committee members. I would like to express my sincere appreciation to Dr. Castro, my major professor and dissertation chair, for her insightful suggestions, guidance, and consistent support. Because of her, I was able to re-embark on my dissertation. I deeply appreciate Dr. Subramaniam, co-chair for his encouragement and the countless hours he spent offering suggestions. I also thank Dr. Hagen for her support and cooperation. A special thanks goes to Dr. Henson for his expertise in educational statistics and ongoing assistance in answering all of my questions in spite of his busy schedule. Without his help, this dissertation could not have been completed.

My sincere appreciation is extended to Dr. Nelson and Dr. Ezzani, who were willing to help me when I desperately needed it. Through them, I had heartwarming and inspiring experiences; I now know what kind of educator I wanted to be. In addition, I want to extend my deepest gratitude to Dr. Joohi Lee and her mother, who are like a second family to me, for their continuous support, encouragement, warmth, and prayers. Dr. Lee has been my mentor, a great supporter, and a close friend throughout my doctoral student life. I am especially grateful to my dear friends, Lakshimi and Yilmin, for their encouragement and emotional support.

Finally, my greatest appreciation goes to my beloved family, particularly my parents, Jaeheon Lee and Sookja Song, for their trust in me and the unconditional love, support, and encouragement they have given me throughout my life. I am grateful they are my parents, and I am proud to be their daughter. This dissertation is dedicated to my parents in utmost respect.

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CHAPTER 1

INTRODUCTION

Background of the Study

As the enrollment of ethnically/racially, culturally, socioeconomically, and linguistically diverse students in early childhood classrooms has increased (Kena et al., 2015), today's teachers often confront with many instructional challenges, particularly when teaching students whose backgrounds are different from their own (Sadker, Sadker, & Zittleman, 2008; Gay, 2010a). This shift in student demographics demands that early childhood teachers be able to successfully teach all students, regardless of their backgrounds. In response to this national need, teacher preparation and other professional development programs have attempted to help early childhood preservice and inservice teachers develop not only strong content and pedagogical knowledge, but also the in-depth cultural knowledge and skills necessary to educate all students (Keengwe, 2010). Particularly, teacher preparation programs have begun offering stand-alone multicultural education courses and other integrated classes including science and mathematics methods courses (Gay, 2010b). These courses help preservice teachers develop a body of cultural knowledge and skills, and integrate it into academic disciplines in ways that highlight educational equity and excellence of individual students.

Despite the current efforts to adequately prepare preservice teachers for diverse classroom settings, a number of studies have raised concerns about teachers' ability to educate such a diverse student population in the standard early childhood science classroom (Johnson, 2011; Ladson-Billings, 2007; Lee & Buxton, 2010; Lee, Luykx, Buxton, & Shaver, 2007; McLaughlin, 2014; Mutegi, 2011). Specifically, prominent scholars in science education (Lee et al., 2007; Southerland, Golden, & Enderle, 2012) and other multicultural researchers (Hollins &

Guzman, 2005; Magogwe & Ketsitlile, 2015; Siwatu, 2011a, 2011b; Vedder, Horenczyk, Liebkind, & Nickmans, 2006) have contended that many early childhood preservice and inservice teachers are still not sufficiently prepared to serve students from diverse backgrounds. For example, Siwatu (2011b) discussed how White female preservice teachers felt underprepared to teach in an urban school context consisting of a diverse student population, though they didn't have the same feelings of inadequacy in a suburban school context. Another study of Siwatu (2011a) showed that preservice teachers felt less confident in their ability when required to integrate their teaching practices for students with cultural and linguistic diverse. He stressed that this was a serious problem, because if teachers were not prepared to work with a diverse student population, they could not provide appropriate instruction (Hutchison, 2014; Pringle & McLaughlin, 2014).

As a result of this limited teacher preparation, students from diverse backgrounds have found it difficult to learn science. This has been evidenced by national and regional data indicating a consistent gap in science achievement across various groups of students (Grigg, Lauko, & Brockway, 2006; Kena et al., 2015; Mensah, 2013; Muller, Stage, & Kinzie, 2001; National Assessment of Educational Progress, 2006; Norman, Ault, Bentz, & Meskimen, 2001; O'Sullivan, Lauko, Grigg, Qian, & Zhang, 2003). Also, the achievement gap has been shown to begin very early in a student's education (Chapin, 2006; Morgan, Farkas, Hillemeier, & Maczuga, 2016; Mulligan, McCarroll, Flanagan, & Potter, 2014). For instance, Mulligan et al.'s (2014) research with the Early Childhood Longitudinal Study, Kindergarten Class of 2010-11(ECLS-K) found science achievement gaps among students of difference races/ethnicities, genders, levels of English language proficiency, and socioeconomic statuses. The study indicated that average science scores differed vastly by students' race/ethnicity. White, Asian, and multi-racial students had higher average scores than did either Black or Hispanic students. Furthermore, the study revealed that students whose primary home language was English scored higher than their counterparts, and male students outperformed female students. With regards to different income groups, students in households with incomes below the federal poverty level scored the lowest, whereas students in households with incomes at or above 200% of the federal poverty level scored highest. Along with these findings, similar achievement patterns were observed in average science scores at fourth, eighth, and twelfth grades, according to results from the National Assessment of Educational Progress (NAEP) administered in 2009 and 2011 (Kena et al., 2015).

Supporting the claims above, Morgan, Farkas, Hillemeier, and Maczuga (2016) and Curran and Kellogg (2016) also indicated that science achievement gaps emerged as students entered kindergarten. In particular, Morgan et al. (2016) revealed that in terms of science achievement, students from White and high-income families outperformed low-income and language/ethnic minority families when entering kindergarten. Students from low-income and linguistic/ethnic minority families began kindergarten with low initial science knowledge, and they were inclined to continue struggling in this subject area until the eighth grade. Another noticeable finding of this study was that early achievement in science learning was a significant indicator of later success in that area. More specifically, children's initial science knowledge in kindergarten was the strongest predictor of their initial science knowledge in the first grade. Accordingly, the initial science knowledge in the first grade was the most significant predictor of their science achievement in the third to eighth grades.

Morgan et al. (2016) and other researchers (Goldenberg, 2014; Ladson-Billings, 2006; Milner, 2010; Norman et al., 2001) have sustained that ethnically/racially, culturally, socioeconomically, and linguistically diverse students' underachievement in science was the result of an *opportunity gap* in learning. They attributed this gap to the historical and continuous socioeconomic inequity faced by traditionally marginalized groups. Additionally, they specified that students from linguistic/ethnic minorities and low-income families experienced an opportunity gap in both informal and formal schooling (Morsy & Rotherstein, 2015). Other studies have indicated that such students were more likely to attend low-quality childcare and preschools (Cascio & Schanzenbach, 2013; Hillemeier, Morgan, Farkas, & Maczuga, 2013; Ramani & Siegler, 2008). Coming from inferior institutions, they were likely to have less exposure to science knowledge, materials, and activities than their counterparts from White and high-income families (Ladson-Billings, 2007). Also, they were less likely to receive a high-quality, inquiry-driven science education, which impeded their science learning in early childhood.

Students from diverse backgrounds come to school with their own unique *learning habits*. This individuality is constructed by the influence of "learning styles, developmental levels, social economic status, learning experiences, religion, social class, race/ethnicity, sexual orientation, and physical and mental abilities" (Keengwe, 2010, p. 2). However, teachers have traditionally used a "one-size-fits-all" approach for teaching science to all students, which does not consider their varied backgrounds and different levels of science knowledge and skills (Roehrig & Luft, 2006). That is, students' prior knowledge/experience, culture, and language, developed in their homes and communities, have been ignored or rejected by teachers. One can surely assume that students from diverse backgrounds have consistently experienced an opportunity gap in the formal education system.

In this regard, many educational researchers have argued for issues of diversity and social justice to be made integral to early childhood science education (Barton, 2003; Basu, 2010; Johnson, 2011; Santos, 2008). Numerous examinations of teaching practices have identified *cultural awareness* as a significant characteristic that early childhood preservice teachers must develop to be successful in diverse classroom settings, in order to ensure that equitable science learning opportunities can be made available to all students (Brown, 2004a; Gay, 2002; Ladson-Billings, 2009; Sanders, Haselden, & Moss, 2014; Villegas & Lucas, 2002). Lee, Deaktor, Hart, Cuevas, and Enders (2005) emphasized that when a teacher acknowledges, values, and integrates students' cultural diversity into their science curricula, science becomes "accessible, relevant, and meaningful" to all students (p. 858). Other scholars believed that by gaining a deep understanding of culture in teaching and learning, early childhood preservice teachers would be able to establish sound and equitable science pedagogy, and thus young diverse learners can achieve their full social and academic potential (Bianchini & Brenner, 2010; Gay, 2000; Lim & Able-Boone, 2005; Smith, 2004).

Statement of the Problem

Given the emphasis on *cultural awareness* as a significant element for preparing early childhood teachers for diverse classrooms, there has been a remarkable movement among teacher preparation programs and educational researchers to promote preservice teachers' cultural awareness. As of today, many studies have been conducted on the effectiveness of interventions for building preservice teachers' sense of cultural awareness, addressing such topics as the impact of (a) having field experience (Deering & Stanutz, 1995; Jacobsen, 1999; Walker-Dalhouse & Dalhouse, 2006), (b) using reflective writing after field experience (Kyles &

Olafson, 2008), (c) using refection alone (Sanders et al., 2014), and (d) taking multicultural education courses (Brown, 2004b; Larke, 1990; Russell & Russell, 2014). Also, researchers have attempted to explore the factors most influential for developing preservice teachers' cultural awareness, both in and out of programs (Dedeoglu & Lamme, 2011; Garmon, 2004; Kahn, Lindstrom, & Murray, 2014).

Even though teachers' cultural awareness has been heavily emphasized to be essential to the provision of equitable learning opportunities to all students, the field of science education has paid scant attention to how preservice teachers' *cultural awareness* was associated with their *self-efficacy* in equitable science teaching. Furthermore, how preservice teachers would perceive equity in science education and how their future instructional strategies would differ for students from diverse backgrounds by incorporating the equity concept have not been sufficiently acknowledged.

Purpose of the Study

The current study was designed with a tri-fold purpose to respond to certain gaps in the early childhood science literature. Bandura (1977, 1986, 1997, 2006) and other teacher self-efficacy researchers (Klassen, 2010; Klassen & Chiu, 2011; Schunk & Pajares, 2009; Siwatu, 2007) have claimed self-efficacy to be a strong predictor of future teaching behaviors and performance. Given Bandura's (1982) claim that there was a link between strong self-efficacy and individual performance, this study sought to examine if preservice teachers' cultural awareness predicted their self-efficacy in equitable science education. Also, using preservice teachers' demographic characteristics (e.g., ethnicity/race and the number of languages they speak), this study aimed to determine if the relationship between cultural awareness and self-efficacy in equitable science education was moderated by these demographic factors. Finally, by administering open-ended questions, this research attempted to identify how preservice teachers perceived equity in science education and how they planned to incorporate equity in science education into their future science teaching, particularly when teaching students of diverse races/ethnicities, languages, cultures, and socioeconomic statuses. Thus, the investigation of both preservice teachers' sense of self-efficacy in equitable science teaching and learning and the future instruction for particular groups of students, while relating to cultural awareness, can reveal why the opportunity gap in learning persists in science classrooms.

Research Questions

The current research explored the relationship between early childhood preservice teachers' awareness of cultural diversity on their self-efficacy in equitable science teaching, while identifying moderating factors. This study also investigated what preservice teachers perceived as equitable science teaching for diverse groups of students. Accordingly, this study attempted to answer these initially raised research questions:

1. To what extent was early childhood preservice teachers' cultural diversity awareness related to their self-efficacy in equitable science teaching and learning?
2. Did early childhood preservice teachers' race/ethnicity or the number of languages they speak moderate the relationship between their cultural diversity awareness and self-efficacy in equitable science teaching and learning?
3. How did early childhood preservice teachers conceptualize equity in science education?
4. How did early childhood preservice teachers plan to incorporate equity in science education into their future science teaching practices for ethnically/racially, linguistically, culturally, and socioeconomically diverse learners in early childhood classrooms?

Significance of the Study

The current research has significant social and academic implications in a sense that the focus was on timely issues of equity and diversity in science learning. There were groups of researchers consistently indicating that young students from diverse backgrounds have not received a fair opportunity to learn science (Gay, 2000; Howard, 2010; Ladson-Billings, 2009; Patterson, 1997). By providing a connection with them, the findings of the current investigation would be able to contribute to explaining why inservice teachers might be providing inequitable science education to these students and why the achievement gap persisted, because the demographic makeup of preservice teachers was parallel to that of the teaching force in public pre-K to grade 12 classrooms (Busey & Waters, 2016).

For preservice teachers, developing pedagogical knowledge or pedagogical content knowledge without understanding how their own culture may differ from that of their future students is analogous to building a house without laying the foundation. Shaklee and Baily (2012) emphasized that identifying preexisting beliefs and experiences was an initial and critical step in becoming competent teachers for demographically diverse students; otherwise, teachers were likely to use their own sociocultural background as a cultural lens to see students from other cultures. Thus, this study's attempt to reveal the levels of preservice teachers' cultural awareness and self-efficacy could help them re-conceptualize their socio-cultural lens, allowing them to accept others' perspectives and develop sound equitable science pedagogy for all.

Equally important, this study suggested a framework for teacher preparation programs that addressed problems with "theory into practice" in early childhood science education. Teacher preparation programs have tried to educate preservice teachers to be culturally knowledgeable and skilled in science teaching in diverse classroom contexts. However, it is difficult to ascertain if preservice teachers are able to conduct appropriate instructional practices, because they are not yet positioned in an actual teaching setting. At this critical juncture, visualizing science teaching strategies for particular groups of students while learning cultural awareness and self-efficacy could contribute to the efforts of researchers searching for solutions to inequitable science education.

Limitations of the Study

Because the focus of the current research was the relationship between cultural awareness and self-efficacy in equitable science teaching and learning, other possible factors (e.g., the levels of science content and pedagogical knowledge) that could influence self-efficacy were not investigated. Thus, future studies should evaluate how these factors impact preservice teachers' self-efficacy in teaching and learning science to diverse learners in relation to cultural awareness.

Definition of Terms

- Culture – Culture includes "ethnicity, racial identity, economic class, family structure, language, and religious and political beliefs, which profoundly influence each child's development and relationship to the world" (National Association for the Education of Young Children [NAEYC], 2012, p. 24).
- Diversity (family and child) – Diversity includes "race, ethnicity, language, culture, social class, immigrant status, special needs, and learner characteristics" (NAEYC, 2012, p. 21).
- Dominant culture/mainstream culture – Dominant culture refers to "the system of mainstream and widely acceptable social practices and ideas, often based on the ways of life of social groups with the most power in our society" (Carter, 2005, p. 185).

- Self-efficacy – Self-efficacy refers to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 3)
- Teachers’ self-efficacy – Teachers’ self-efficacy refers to “teacher’s belief in his or her own capability to organize and execute course of action required to successfully accomplish a specific teaching task in a particular context” (Tschannen-Moran Woolfolk-Hoy, & Hoy, 1998, p. 223).

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

In keeping with the aims of this study, this chapter provides an overview of preservice teachers' awareness of student diversity and the self-efficacy beliefs about equitable science teaching and learning that were identified in the literature. To facilitate an in-depth understanding of the relationship between *cultural awareness* and *self-efficacy*, other related literature was also examined. In short, the literature review below addresses the following topics: (a) the demographic divide in early childhood science classrooms, (b) from deficit to equity in science education and equitable science teaching, (c) culture as a significant influence on teaching and learning science, (d) teachers' cultural awareness, and (e) teachers' self-efficacy.

Demographic Divide in Early Childhood Science Classrooms

The U.S. population has been experiencing dramatic changes, and this trend is reflected in school enrollment. Student demographics in public schools have continued to shift toward greater diversity; students from ethnically, racially, culturally, economically, and linguistically diverse backgrounds are increasing (Kena et al., 2015). This demographic shift has been particularly evident in early childhood classrooms (Snyder & Dillow, 2013). According to a report from the National Center for Education Statistics (NCES), in the kindergarten class of 2010-11, approximately 49% of kindergarteners were non-White, 25% were Hispanic, 14% were Black, 5% were Asian, 4% were multi-racial, 1% were American Indian or Alaskan natives, and less than 1% were native Hawaiian or Pacific Islander. The NCES projected that the enrollment of non-White students would outnumber that of White students by 2024. In addition, 26% of kindergartners lived below the federal poverty threshold, and approximately 16% of the total enrollment spoke a language other than English at home.

Not reflecting these changing student demographics, the teaching workforce in early childhood classrooms has continued to be fairly homogenous; that is, teachers today are still predominantly White, monolingual, middle-class females (Feistritzer, 2011; Flores, Clark, Claeys, & Villarreal, 2007; Kena et al., 2015; Zumwalt & Craig, 2005). A recent report from the NCES (Goldring, Gray, & Bitterman, 2013) noted that during the 2011-2012 school year, 89% of the teaching workforce in public primary schools was female. Although there has been a slightly growing Hispanic influx into the teaching force since 1986, the overwhelming majority of teachers have still been White (81.2%) compared to 8.7% who were Hispanic, 7.1% Black, 1.7% Asian, 0.8% multi-racial, and 0.4% American Indian/Alaskan native.

In response to this demographic discontinuity (i.e., between teachers and students) and the achievement gap (i.e., across the different student groups), current science reform has emphasized an improvement in science learning for all students as its primary goal (NGSS Lead States, 2013). Notably, the current reform movement highlighted the need to bring about diversity and equity in science education and included populations who have traditionally been underserved in science classrooms. It clearly delineated that while focusing on equity and excellence in learning for all students, teachers must have provided equal access and have high expectations and standards so that students could learn rigorous science content. Equal access to science learning for all students took place when teachers implement effective science teaching strategies that capitalized on their knowledge and understanding of student diversity, as well as their students' diverse learning needs (NGSS Lead States, 2013). By emphasizing equitable opportunities for all students, this reform aimed to reduce the achievement gap among students across diverse backgrounds and promote scientific literacy for all. Collectively, the emphasis of the current reform was on equitable science teaching in response to changing student demographics; consequently, it now places greater demands and expectations on today's early childhood teachers.

From Deficit to Equity in Science Education

Traditionally, a *cultural deficit model* had been adopted in the United States to understand and instruct particular groups of students who were culturally, linguistically, and ethnically/racially diverse (Sleeter & Grant, 1987). The model ascribed these students' academic failure to a lack of preparedness, primarily attributing their failure to students themselves, their families and communities (Valencia & Solorzano, 1997). This ill-preparedness included, but not limited to, students' limited intellectual abilities, lack of motivation, immoral behavior, linguistic deficiencies, and cultural differences. Teachers who advocated for this model were prone to unfairly and disproportionately categorize such students into lower ability groups or special education classes. They were categorized as being "at risk," meaning that teachers needed to "fix" their deficiencies (Barba, 1998; Farkas, 2003). Such teachers' perceptions and teaching practices resulted in unequal access to quality learning opportunities and students' persistent underachievement, which threatened their educational equity (Farkas, 2003; Oakes, 1995). Consequently, the inequity in education led to an education crisis in the U.S., and thus, it had become a critical issue for policy makers, researchers, and the public.

With the Civil Rights movement of the late 1960s and early 1970s, several educational reforms were generated to pursue educational equity for all students. Particularly, the 1980s was a significant era in science education. During this decade, several science reforms were also initiated, including *Project 2061* and *Science for All Americans*, which were published in 1985 and 1989, respectively, by the American Association for the Advancement of Science (AAAS). *Project 2061* and *Science for All Americans* attempted to include all students in science education, regardless of age, gender, race/ethnicity, socio-economic status, and disability, stressing that all students are capable of learning science. Both initiatives were proposed to foster scientific literacy in all students, especially "those who in the past … have largely been bypassed in science and mathematics education: ethnic and language minorities and girls" (AAAS, 1989, p. xviii).

More importantly, *Science for All Americans* brought remarkable changes in science education; it served as the cornerstone of the current efforts to reform K-12 science education. First, *Science for All Americans* provided the groundwork for developing the *Benchmarks for Science Literacy* (AAAS, 1993) and *National Science Education Standards* (NSES) (National Research Council [NRC], 1996) for teachers and students in grades K-12. Then, the *Benchmarks for Science Literacy* suggests a broad set of sequential learning goals to help teachers design their core curricula in ways that assist students in achieving the benchmarks outlined in *Science for All Americans*. Also, the NSES details what students should know and be able to do in K-12 science classrooms.

Aligned with the notion of equity championed in the previous reforms, the recent *Framework for K-12 Science Education* (NRC, 2012) was published; under this framework, the new *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013) was developed. These reforms diverge from the NSES by stating that students needed to "actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields'' (NRC, 2012, pp. 8-9). In addition, they addressed diversity and equity issues in their content; these issues were reflected in the language used throughout the reform document. According to Lee, Miller, and Januszyk (2014), the NGSS had attempted to employ “inclusive language (e.g., scientists and engineers from diverse backgrounds), relevance of science to students’ lives (e.g., real-world problems, local contexts), and low-cost science supplies in consideration of districts or schools with limited resources” (p. 227). These efforts were situated in the principle that when science instruction was “inclusive and sensitive to diverse cultures” (Lee, Miller, & Januszyk, 2014, p. 227), it became more accessible, relevant, and meaningful to all students. The new reforms expected to close the achievement gap across various student groups and ultimately yield more scientifically literate citizens.

Equitable Science Teaching

Equitable science teaching practices take into account each student's differences and use those differences to make instructional decisions, tailoring teaching practices to students’ individual learning needs. In establishing high standards and expectations for all, the goal of equitable science teaching is to make science curricula accessible, relevant, and meaningful to all students. It is grounded on the tenet that all students, regardless of race, ethnic group, gender, socioeconomic status, geographic location, age, language, disability, or prior science achievement, can become scientifically literate through equitable/equal opportunities to learn (NRC, 1996, p. 221). This manner of teaching ensures that all students are able to engage with scientific practices and construct knowledge through meaningful learning in their science classrooms. This is important because regardless of student groups, students’ levels of engagement and the challenges they meet from teachers’ high expectations and standards will affect their level of science achievement (Southerland, Golden, & Enderle, 2012).

Lee and Buxton (2010) noted that equitable opportunities for learning science take place when school science: “(a) values and respects the experiences that students bring from their home and community environments, (b) articulates this cultural and linguistic knowledge with disciplinary knowledge, and (c) offers sufficient educational resources to support science learning” (p. 11). Namely, early childhood teachers must be able to access the funds of knowledge that students and their families from diverse backgrounds share, and understand what additional resources need to be made available for those students to learn (Moll, Amanti, Neff, & Gonzalez, 1992). As a basis of practicing equitable science teaching, they need to identify cultural similarities and differences between themselves and their students and between their students and science (Young, 2010). They also need to develop a deep understanding of how these cultures affect both teaching and learning (Southerland, Gallard, & Callihan, 2011).

Culture as a Significant Influence on Teaching and Learning Science

Conceptualized from a psychological perspective, culture is described as the psyche affecting human behavior. Samovar and Porter (1991) defined culture as a medium affecting all aspects of human life (e.g., the formation of personality and the ways of thoughts and acts). Parsons and Carlone saw culture as a system of “implicit and explicit beliefs and values” that influence “how individuals perceive and interact with the world” (2013, p. 2). Beliefs and values are considered “bounded, coherent, static, unchangeable, and cumulative” and “transmitted from one individual or generation to another” (p. 2). Similarly, Lustig and Koester (2003) and many other researchers (Grimberg & Gummer, 2013; Pai, Adler, & Shadiow, 2006) defined culture as a learned set of shared norms, values, beliefs, and expectations that affect people’s behaviors in a group.

Culture is frequently cited in analyses of issues of equity in science education because it has significant implications, particularly where the demographic divide between teachers and students exists. Gay (2010b) and Ladson-Billings (2009) regarded culture as the single strongest factor affecting the beliefs, attitudes, values, expectations, and behaviors of both teachers and students. Unquestionably, teaching and learning occur via human interactions between teacher and student through talking, acting, and thinking, all of which reflect individual cultural values, norms, and upbringing (Erickson, 2002; Gutierrez, 2002; Ladson-Billings, 1995; Lee, 2007; Mohatt & Erickson, 1981). In this respect, science teaching and learning should be contextualized and interpreted within the context of each individual's broad background, including their race, ethnicity, language, socioeconomic status, gender, and sexual orientation (Jurow, Tracy, Hotchkiss, & Kirshner, 2012).

The same cultural process is applicable to science education. Norman et al. (2001) noted that when learning science, students from diverse backgrounds interacted in "significant and sustained ways" they acquired from their cultural backgrounds. They referred to sites of interaction as "cultural interface zones" (p.1130). Cultural interfacing takes place at three cultural points: teachers, students, and science. In other words, as cultural beings, students from diverse backgrounds confront two cultures – science and teachers – when learning science. For successful science learning, Norman et al. (2001) emphasized the importance of transmuting "sites of cultural conflict to sites of cultural cooperation" (p.1104). Accordingly, it is necessary to identify how the cultures of both science and teachers differ from that of non-mainstream students.

Culture of Science and Its Influence on Students' Learning

Science education has privileged only a few selected groups of students, predominantly those from White and high-income families (Norman et al., 2001). On the other hand, students from diverse backgrounds have been traditionally underserved in their science classrooms (Lee & Fradd, 1998; Mullis et al., 1994; National Science Foundation [NSF], 1994; Parsons, 2008). Also, they have been less successful in science learning than their more privileged counterparts (Darling-Hammond, 2014), and have been underrepresented in science-related careers (Langdon, McKittrick, Khan, & Doms, 2011; NSF, 2015).

Many scholars have attributed this imbalance of science achievement to science's cultural aspect, locating it in the Western and Eurocentric tradition (Davison & Miller, 1998; Gallard, 2007; Lee, 1999, 2003; Lee & Luykx, 2006, 2007; Loving, 1997; Matthews, 2011). From their perspective, science originated in the philosophy of ancient Greece and the Renaissance, so science incorporates human practices that resonate with its associated Western and Eurocentric culture, including its norms, values, and beliefs (AAAS, 1989; Abd-El-Khalick & Lederman, 2000; Bianchini, Johnston, Oram, & Cavazos, 2003; Grimberg & Gummer, 2013; McComas, 1998; NRC, 1996; Taconis & Kessels, 2009). In this sense, practicing science in school enforces students from culturally, linguistically, and racially/ethnically diverse backgrounds to engage with the Western and Eurocentric culture.

Contrary to these scholars' stance that school science is a cultural construct, many teachers seem to hold a different notion that science is a value- and culture-free subject due to its absolute and universal characteristics (Cobern & Loving, 2000; Kahle, Meece, & Scantlebury, 2000; Lee & Buxton, 2008; Lee & Luykx, 2007; Luykx & Lee, 2007; Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006; Stanley & Brickhouse, 1994, 2001; Roth & Tobin, 2007). This fallacy, however, misleads teachers into believing it is unnecessary to provide accommodations to students from diverse backgrounds as they attempt to learn science.

However, as those scholars claimed, this “nature of science” is incompatible with the cultures of students from diverse backgrounds. As other students do, these diverse learners develop ways of understanding the world through the personal experience, skills, knowledge, values, attitudes, beliefs, and ways of thinking they’ve constructed in their home and community environments, and enter early childhood classrooms with their own cultural schemata. Unfortunately, these students’ views and ways of knowing science in their respective cultures are often different from the requirements of the essential practices of scientific inquiry (Aikenhead & Otsujui, 2000; Atwater, Freeman, Butler, & Draper- Morris, 2010; Bianchini, Cavazos, & Rivas, 2003; Bryan & Atwater, 2002; Lee, 2003). In certain cultures, for examples, the causes of natural phenomena (hurricanes and tornadoes) may be explained by religious beliefs or local fairy tales, rather than by science. This example highlights the vital role culture plays in how children interpret and respond to the world around them.

As described above, students may interpret natural phenomena in non-scientific ways associated with their culture. In such cases, if teachers account for their reasons through a scientific approach without bridging to students’ cultural knowledge, a cultural conflict occurs. Thus, Norman et al. (2001) contended that such students needed additional help from their teachers to smoothly connect their different cultural interface zones. They emphasized that teachers needed to acknowledge that school science had a cultural aspect that did not align with students’ culture. They also proposed that instead of the traditional ways of teaching science, it was necessary for teachers to infuse students’ cultural capital into their teaching practices. These pedagogical activities should have been aligned with “learners’ culture, language, and ways of thinking" to bridge science culture. Teachers needed to help students establish the "habits of mind of western science" (Southerland et al., 2011, p. 2184). In this way, science learning could become accessible, relevant, and meaningful to early childhood students from diverse backgrounds, promoting their inclusion in science classrooms.

Teachers' Culture and Its Influence on Science Teaching

As emphasized earlier, a majority of teachers in the U.S. are White, monolingual English speakers and middle-class females; however, their students' demographics are much more diverse. Much educational research, including Delpit (2012), Howard (2006), Johnson (2011), Irvine (2003), Nieto (2013), Reiter and Davis (2011), and Sleeter (2001, 2008, 2011), has pointed out that the demographic divide between teachers and students connotes cultural discontinuity. This cultural discontinuity is noteworthy in that it makes both science teaching and learning difficult. The impact of this cultural discontinuity on education has been well documented in the literature. It includes the following: (a) a misunderstanding of the cultural styles of diverse learners, (b) a lack of knowledge about the cultural impact of learning, (c) low academic and behavioral expectations for diverse learners, and (d) a lack of integration of multicultural learning experiences into academic disciplines (Allen & Boykin, 1992; Boykin & Cunningham, 2001; Downey & Pribesh, 2004; Rowser & Koontz, 1995; Walker-Dalhouse & Dalhouse, 2006).

Several empirical studies have maintained that the cultural matching of teachers and students by race/ethnicity yields positive academic outcomes across various subjects taught in early childhood classrooms (Clewell, Puma, & McKay, 2005; Easton-Brooks & Eddy, 2011; Easton-Brooks, Lewis, & Zhang, 2010). For example, the science achievement of students from varied backgrounds was higher when their teachers had similar upbringing. These studies also found that such teachers sufficiently bridged students' culture in academic subjects with support from their rich experiences and perspectives.

Hollins and Guzman (2005) and Skerret (2008) noted that teachers' socio-cultural backgrounds guided their overall instructional methods. Teachers were inclined to develop their own experiences, understanding, expectations, and biases within their unique social and cultural contexts and bring these middle class, western-centric perspectives into classrooms (Keith, 2012). As a consequence, they typically implemented a Eurocentric pedagogy for teaching all of their students (Delano-Oriaran & Meidl, 2013; Howard, 2006; Ladson-Billings, 2009), which often conflicted with their students' culture.

McLaughlin (2014) and Taconis and Kessels (2009) claimed that teachers who implemented a Eurocentric pedagogy in teaching science forced students from diverse backgrounds to acculturate to fit into mainstream science and their teachers' cultures, both of which resonated middle-class, European American cultural values and norms. They forced the students to adapt to "dominant norms of punctuality, communicative expression, styles of thinking, and standards of behavior" when learning science (McLaughlin, 2014, p. 901). Regarding cultural enforcement, Grimberg and Gummer (2013) asserted that when education was forced to be a medium of the dominant culture, a conflict occurred between culture and education.

Teachers' Cultural Diversity Awareness

Developing cultural diversity awareness and sensitivity is a critical step toward being an effective teacher in a multicultural setting (Irvine, 1992; Gay, 2000; Larke, 1990; Nietro &

Booth, 2010; Russell & Russell, 2014; Villegas & Lucas, 2002). Nietro and Booth (2010) affirmed that it was the obligation of all educators to be aware of various worldviews in order to understand individual students' cultural heritage; otherwise, "it is psychological and moral violence to the dignity and worth of that individual" (Pai et al., 2006, p. 22).

Brown (2004a) defined cultural diversity awareness as "the continuous modification of one's belief system by 1) seeking out and internalizing accurate knowledge of one's own cultural frames-of-reference and the cultures of 'others,' 2) recognizing and respecting the contributions of 'other' (macro/micro) cultures to the progress of a society, 3) valuing, understanding, and participating in cross-cultural interactions, and 4) nurturing equitable behaviors in one's 'self' and 'others'" (p. 112). As Brown described (2004a), cultural diversity awareness is a key element for all teachers in diverse classroom contexts in that it could help them understand the needs of students from diverse backgrounds and also develop and implement appropriate teaching strategies for their needs (Brand, 2014; Villegas & Lucas, 2002). Prior research has supported this idea, stating that teachers with a strong sense of cultural diversity awareness were more likely to employ equitable teaching practices, including setting higher student expectations, administering unbiased assessments, and providing equitable access to various materials (Banks, McGee, & Cherry, 2001; Diller & Moule, 2005; Gay, 2000). They also effectively and appropriately collaborated with students and their families (Mahon, 2006; Plata, 2011; Sleeter, 2008).

However, not all teachers are highly aware of diverse student cultures. A substantial body of research has shown that many White teachers held deficit views of students with culturally, linguistically, socio-economically, and ethnically/racially diverse backgrounds and tended to ignore students from circumstances different from their own (Bryan & Atwater, 2002; Boutte, 2008; Irvine, 2003; Lee et al., 2007; Reiter & Davis, 2011); as a consequence, they may have become biased toward such students and their families and have lower expectations of students' academic abilities (Reiter & Davis, 2011). These educators did not feel responsible for addressing differences in language, culture, and opportunities to learn (Carter, Larke, Singleton-Taylor, & Santos, 2003; Hollins & Guzman, 2005; Lee et al., 2007; Sleeter, 2001). Furthermore, Kumar, Karabenick, and Burgoon (2012) and Tennenbaum and Ruck (2007) found that many White teachers even demonstrated their implicit preference for White students over other groups of non-White learners. The teachers' implicit evaluation of different cultural groups negatively affected teaching behaviors such as their academic expectations as well as their manners of speech and referral.

In addition, many White teachers had limited cross-cultural knowledge and experience (Irvine, 2003; Johnson & Atwater, 2014). The lack of knowledge and experience could cause them to erroneously assume that their students are a mono-cultural group (Irvine, 2003); consequently, they failed to identify their students' diversity and meet their various learning-related needs (Ladson-Billings, 2009). In addition, if teachers did not have the opportunity to reflect on the structural inequity of our society, they would be likely to consider themselves a part of the norm and not be aware of their privilege as members of the dominant cultural group (Tatum, 1992). As a result, their values and principles tended to be used to judge students from diverse cultures (Keith, 2012), which was considered a universal tendency for human beings (LeVine & Campbell, 1972).

Preservice Teachers' Cultural Diversity Awareness in Science Teaching

From the ample evidence that cultural diversity awareness affects teachers' perceptions and instructional practices, it can be assumed that a high level of cultural awareness is likely to produce equitable opportunities to learn science. In line with this perspective, much research has been conducted on preservice teachers' attitudes, experiences, and perceptions of student diversity in order to identify problems and better prepare them for diverse early childhood science classrooms.

Russell and Russell (2014) examined preservice science teachers' cultural diversity awareness using the Cultural Diversity Awareness Inventory. Their findings suggested that although the preservice teachers they examined revealed some awareness of the cultures, languages, and ethnic identification of their culturally and linguistically diverse students, they did not perceive their own culture as different from that of their students. Also, these preservice teachers showed a preference for working with students from the same ethnic and cultural backgrounds as their own, which was consistent with the findings of Kumar et al. (2012).

Castro (2010) identified and compiled the patterns of preservice teachers' views on student diversity, multicultural education, and social justice by analyzing articles published from 1985 to 2007. His findings indicated that preservice teachers were not aware of how society and schooling in the U.S. were structured to benefit a White population (Chizhik & Chizhik, 2005; Mueller & O'Connor, 2007; Weisman & Garza, 2002). They also continuously demonstrated a lack of understanding of multicultural education. For example, they were willing to teach in multicultural classrooms but misunderstood and misinterpreted multicultural education, diversity, and the attitudes and skills necessary to teach diverse students (Middleton, 2002). McLaughlin (2014) asserted that such misinterpretations could be attributed to a mismatching of the backgrounds of preservice teachers to those of their students, and that could serve as a "formidable barrier" to science teaching and learning.

Castro (2010) found another pattern which was consistent with the previous findings. According to him, many White preservice teachers held stereotypical beliefs and deficit thinking about the learning abilities of a particular group of students, and were unwilling to teach them (Bakari, 2003; Baldwin, Buchanan, & Rudisill, 2007). A recent study of Southerland et al., (2011) also confirmed that many preservice teachers identified specific traits of students (e.g., their culture, economic class, primary language, and ethnicity) as the most difficult hurdles to overcome when teaching science. However, other studies have shown more positive orientations to cultural diversity among preservice teachers (Dee & Henkin, 2002; Siwatu, 2007).

In addition to these contradictory attitudes and perceptions of student diversity, preservice teachers' beliefs about cultural diversity, social justice, and multicultural education were positively changed by interventions such as multicultural courses, tutoring or mentoring projects, and field-based and instructional practices (Bell, Horn, & Roxas, 2007; Brown, 2004b). Kumar and Hamer's (2012) conclusions were consistent with these prior studies. They found evidence that after completing their teacher preparation program, preservice teachers were significantly less biased against students from diverse backgrounds and more likely to endorse adaptive instructional practices.

Other studies also found that preservice teachers who had prior experiences with diverse cultures and who previously had been marginalized were more likely to support multicultural education and teaching, and showed appreciation for cultural diversity (Adams, Bondy, & Kuhel, 2005; Garmon, 2004). With regards to the importance of prior experience in cultural diversity awareness, Sleeter (2008) maintained that preservice teachers' lack of exposure to cross-cultural experiences could lead to a failure in recognizing racial and ethnic inequality, and cause them to adopt a colorblind approach in their teaching.

In fact, the colorblind approach has been predominantly used in educational settings, including early childhood classrooms. Many preservice and inservice teachers believed that it was the best means of teaching diverse students (Hachfeld, Hahn, Schroeder, Anders, & Kunter, 2015). However, this method does not respect differences among the various ethnic and cultural groups, and it contains the contrast notion of equity; instead, the colorblind approach promotes equality and inclusion (Southerland et al., 2011). Equity is an important tenet of the current science education reform; however, related studies have noted that most of preservice teachers did not clearly grasp the meaning of multiculturalism, equity, or diversity (Gayle-Evans & Michael, 2006; Gollnick & Chinn, 2015; Middleton, 2002). Therefore, they did not clearly know how to infuse this body of knowledge into their science curricula.

Hachfeld et al. (2015) conducted an in-depth investigation into how multicultural and colorblind beliefs were associated with important aspects of professional competence. They found a statistically positive association of preservice teachers' multicultural beliefs with self-efficacy and enthusiasm for teaching immigrant students. Also, preservice teachers with multicultural beliefs were less likely to hold stereotypes about students and their families in terms of academic motivation and support. On the other hand, colorblind beliefs were negatively related to a willingness to change teaching styles to accommodate these diverse students. The differences were all statistically significant.

Teachers' Self-Efficacy

Educational researchers and practitioners have been interested in teacher self-efficacy since the late 1970s. The self-efficacy construct was first conceptualized by Albert Bandura (1977). Bandura has been a well-acknowledged and most cited scholar in establishing the foundation of the term *self-efficacy*, which is still actively applied not only to science teaching but also to various fields of inquiry. Grounded on his Social Cognitive Theory, its major premise includes the notion that human cognition influences behavior. He defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). That is, one's perceived ability to perform a behavior causally influenced the expected outcomes of that behavior. When applying the concept in a teaching context, teacher self-efficacy referred to a "teacher's belief in his or her own capability to organize and execute course of action required to successfully accomplish a specific teaching task in a particular context" (Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998, p. 223).

Bandura (1977) proposed two dimensions of self-efficacy as a basis for a person's choice of behavior: personal efficacy and outcome expectancy. Personal efficacy corresponds to a person's judgment regarding his or her ability to perform a specific task, whereas outcome expectancy is a person's belief that his or her behavior will produce a desirable outcome. Both dimensions are measures of self-efficacy, but they work independently because although people believe that a specific action will produce certain outcomes, they may not trust that performing the action will lead to the desired results. For example, even though teachers may be confident in their ability to teach science effectively, they may doubt that their students could earn high scores in science (because of their low level of intelligence, lack of attention, etc.).

Bandura (1977, 1986, 1997) characterized self-efficacy beliefs, which are perceptions of individuals' ability to perform and achieve anticipated outcomes, as a central regulator of one's behavioral changes. Given sufficient incentive and the prerequisite subskills, self-efficacy beliefs govern human functioning in numerous ways, including setting goals, selecting activities, putting in the necessary amount of effort, and demonstrating a coping ability during obstacles and adverse experiences. Due to the tendency of self-efficacy beliefs to predict future actions in all aspects of people's lives (Bandura, 1977), a teacher's perception of self-efficacy is important; it is a powerful predictor of their teaching praxis.

Since Bandura's early theoretical research on self-efficacy, the value and power of teachers' sense of self-efficacy in teaching and learning have been well-established in the literature (e.g., Gencer & Cakiroglu, 2007; Tschannen-Moran & Woolfolk-Hoy, 2007; and Yılmaz & Çavaş, 2008). Much research has indicated that self-efficacy impacted not only teachers' instructional behaviors, including lesson duration and frequency (Pell & Jarvis, 2003; Schoon & Boone, 1998; Schunk, Pintrich, & Meece, 2008) and commitment (Chesnut & Burley, 2015; Jones & Carter, 2007; Lumpe, Haney, & Czerniak, 2000; Schunk et al., 2008), but also student motivation and achievement (Bolshakova, Johnson, & Czerniak, 2011; Tschannen-Moran et al., 1998). As a result, many researchers have claimed teachers' self-efficacy beliefs to be one of the key determinants of successful educational outcomes (Henson, 2001; Palmer, 2006).

Preservice Teachers' Self-Efficacy Beliefs about Equitable Science Teaching and Learning

As aforementioned literature suggested, it is necessary for early childhood preservice teachers to develop a strong sense of self-efficacy in their science teaching. However, there is one particularly significant aspect that many researchers have overlooked in teacher self-efficacy studies in science education; that is to say, scholars have tended to focus on investigating teachers' efficacy beliefs in science teaching but mostly excluded specific teaching contexts.

Self-efficacy is not a stable construct; instead, it is a context-dependent and content-specific paradigm (Bandura, 1977, 1986, 1997; Tschannen-Moran & Woolfolk-Hoy, 2007). In other words, depending on the school or classroom setting in which a teacher is placed and the subject matter taught, a teacher's self-efficacy fluctuates. For instance, although early childhood teachers feel efficacious in teaching science to students with similar cultural backgrounds, they may feel less efficacious when teaching it to diverse student populations. In regard to this particular trait, Siwatu (2011b) used two different school contexts to examine a single group of 34 preservice teachers' changes to their self-efficacy beliefs related to culturally responsive teaching. A majority of the preservice teachers were White females, and their self-efficacy was measured within both suburban (i.e., less diverse, mainstream culture) and urban school contexts (i.e., more diverse, non-mainstream culture) by using the Culturally Responsive Teaching Self-Efficacy (CRTSE) instrument. The findings indicated that preservice teachers' self-efficacy in a suburban school setting was significantly higher than in an urban school setting. Based on evidence from both empirical studies and its related theory, it can be assumed that if early childhood preservice teachers feel efficacious in the praxis of equitably teaching science in a diverse context, they are more likely to successfully provide equitable/equal opportunities for their students to learn science.

Considering the importance of having the contextual factor that may affect self-efficacy beliefs in science teaching, Ritter, Boone, and Rubba (2001) developed the Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument. This instrument extends an existing instrument, the Science Teaching Efficacy Belief Instrument-Preservice (STEBI-B) of Enochs and Riggs (1990), to address issues of self-efficacy related to preservice teachers' beliefs about diversity and their ability to teach science effectively to diverse student populations. The SEBEST retains two subscales of the STEBI-B instrument, Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Efficacy (STOE), but students' sociocultural aspects, such as race/ethnicity, gender, language, or socioeconomic status, were integrated with each item in the two scales. The PSTE on the SEBEST queries preservice teachers about how they perceive their ability to affect student outcomes while associating with students' sociocultural backgrounds. On the other hand, the STOE assesses preservice teachers' beliefs that regardless of the impact of students' sociocultural backgrounds, student outcomes can be positively affected by their effective teaching.

Settlage, Southerland, Smith, and Ceglie (2009) examined the difference between preservice teachers' self-efficacy beliefs about science teaching and equitable science teaching by using both the STEBI-B and SEBEST instruments. Also, they measured changes of self-efficacy along three different points: at the beginning of a science methods course (Time 1), at the end of that same course (Time 2), and at the end of the student teaching experience (Time 3). In addition to this quantitative approach, after the subjects completed their student teaching, the researchers interviewed those preservice teachers who had taught in homogenous (i.e., White, middle-class) classrooms, as well as those who were placed in culturally, linguistically, and socioeconomically diverse schools; the goal was to investigate their attitudes toward teaching in the two different settings. The findings revealed that preservice teachers possessed high levels of teaching self-efficacy in relation to both general public (i.e., STEBI-B) and specific student subgroups (i.e., SEBEST) before learning any methods for teaching science. Surprisingly, most participants' PSTE and STOE for students' diversity in gender, ethnicity, and socioeconomic status on the SEBEST were much higher than for the general public (i.e., STEBI-B); on the other hand, they scored the lowest in estimating their ability to teach science to English language learners. Furthermore, their PSTE and STOE in the STEBI-B showed a statistically significant increase over time (between Time 1 and Time 2 and between Time 1 and Time 3); the same pattern was observed for their PSTE for English language learners (ELLs) via the SEBEST.

The qualitative analysis conducted for this study also showed interesting results. Preservice teachers defined a successful teaching experience in relation to student engagement. Using such descriptors as “fun,” “excited about doing,” or “interested in doing it,” they explained that their teaching was most successful when students were “involved in the process” of their planned activities. When looking at their perceptions of teaching practices for diverse learners, many preservice teachers failed to recognize differences of science learning abilities and interests among the various student groups. Furthermore, they adopted a “one-size-fits-all” approach to teaching science, considering students to be a homogenous group. They believed that all of their students were capable of learning science and got benefits from such science instruction primarily because their lessons were built based on a hands-on inquiry approach. Although a few preservice teachers modified or adapted their lessons for particular groups of students (e.g., ELLs), they were prone to exhibit little practical knowledge of how to tailor their science instruction and felt it was unnecessary to modify their lessons in accordance with diverse learners’ needs.

As a result of the quantitative and qualitative data, it can be assumed that the high initial self-efficacy on the SEBEST scores were not accompanied by a rich knowledge of teaching strategies useful in meeting the learning needs of diverse students. Also, until the preservice teachers completed their student teaching, they could not have been aware of the influence of student culture and language on learning, and they did not acknowledge that their teaching might need to be changed accordingly (the exception was for ELL students). This could, at least partially explain the reason that preservice teachers' self-efficacy in teaching science to diverse student populations did not increase over time, by contrast to the results of the STEBI-B.

Also considered important was research done by Cone, who conducted several research studies using the SEBEST instrument (Cone, 2009a, 2009b). Her research investigated the effects of both community-based service learning (CBSL) experiences and intensive classroom activities in preservice elementary teachers' self-efficacy regarding equitable science teaching and learning; her work was contextualized within a science methods course. For example, Cone (2009a) administered SEBEST at the beginning and end of a semester; at the end of the semester, she also employed an interview method. Her participants were all preservice teachers enrolled in four sections of a science methods course. Sections 1 and 2 explicitly discussed issues of diversity and engaged in activities for increasing diversity awareness. Section 1 was based in a community service center and Section 2 was located on campus. Sections 3 and 4 were also in the community service center and on campus, respectively, but both sections implicitly and limitedly addressed diversity issues and engaged in related activities. The community service center was used by children from low-income families. The children had poor school attendance and unsatisfactory academic achievement on national and state assessments; also, parental involvement was minimal. Preservice teachers in Sections 1 and 3 implemented their inquiry-based science lessons for children at the center, while members of Sections 2 and 4 addressed their peers.

A noticeable finding from this study was the change in PSTE scores between the pre- and post-tests; Section 1 scored significantly higher than Section 4. The PSTE scores of preservice teachers in Section 1 increased significantly over the course of the semester. Supported by the interview results, Cone (2009a) concluded that preservice teachers valued their authentic experiences with diverse student groups; they also expressed a belief that the explicit discussion and activities addressing diversity that occurred in their methods class were major contributors promoting positive changes in their PSTE scores.

Cone (2009b) conducted another in-depth investigation by lessening variances and focusing only on PSTE results. Unlike the above-mentioned study, in this research preservice teachers enrolled in one of two sections of a methods course. In both sections, preservice teachers participated in various activities related to developing diversity awareness, including weekly readings about multicultural education (such as the article “White Privilege”), class discussion about issues surrounding diversity and equity in science education, and multicultural awareness quizzes. The only difference between Sections 1 and 2 was that preservice teachers in Section 1 met at a neighborhood community center every week, while those in Section 2 met at the university’s campus. The results indicate that there was a statistically significant increase in PSTE scores for preservice teachers in both sections. However, closely looking at each section, the methods course supplemented with CBSL was significantly more effective at enhancing PSTE than was the methods section without CBSL. Findings from the qualitative analyses aligned with the findings of the quantitative analysis using the SEBEST. Many preservice teachers in Section 1 reported strong positive changes in confidence levels as a consequence of their CBSL experience; this result was consistent with her prior research study (Cone, 2009a).

It was evident that the CBSL experience contributed to increasing preservice teachers’ PSTE, but its impact alone was insufficient to yield a positive change. PSTE increased when the CBSL was accompanied by explicit discussions and activities related to cultural diversity and equity issues in the methods course. In addition, it is worth noticing what experiences CBSL provides to preservice teachers. From their CBSL, preservice teachers have the opportunity not only to practice their knowledge and skills in science teaching, but also to critically reflect on issues related to diversity in education. These authentic experiences definitely helped promote preservice teachers' cultural awareness; consequently, they ultimately enhanced their self-efficacy in teaching science to diverse learners in this study (Boyle-Baise, 2002; Wade, 2000).

Summary

In early childhood science classrooms, two different cultures confront one another: that of the teachers and that of the students. Whereas students are culturally, linguistically, racially/ethnically, and socioeconomically diverse, teachers are primarily White, middle-class, monolingual females. Unfortunately, many of these teachers are not familiar with their students' diverse backgrounds and not aware of the critical role that culture plays in science teaching and learning. This often leads to the implementation of Eurocentric pedagogy, a system that exclusively reflects the teachers' White, middle-class cultural background (Delano-Oriaran & Meidl, 2013; Howard, 2006). Also, their values and principles are often used to judge students from diverse cultures; therefore, misinterpretations and miscommunications are likely to occur (Middleton, 2002).

Furthermore, school science enforces the habits of mind of western science, which may also contrast with students' ways of knowing science in their own cultures. However, research showed that teachers often did not feel that it is necessary to provide any accommodations to meet their students' learning needs because they believed that science was universal, and thus value- and culture-free (Cobern & Loving, 2001; Lee & Buxton, 2008; Lee & Luykx, 2007). For these reasons, cultural awareness in teachers should be emphasized, particularly when teaching students who are culturally diverse because teachers with a strong sense of cultural awareness are more likely to provide an equitable opportunity to learn.

In response to this issue, concerns have raised as to whether or not early childhood preservice teachers are prepared to teach science in an equitable manner to students from diverse backgrounds. Many researchers have investigated the level of preservice teachers' cultural awareness as well as ways to enhance their awareness. Also, their self-efficacy beliefs in equitable science teaching and learning have examined as a meaningful indicator, especially for preservice teachers because a strong link has been found between robust self-efficacy and teaching performance (Bandura, 1982). However, few studies have investigated preservice teachers' self-efficacy with regards to equitable science teaching and learning in relation with their cultural awareness. The evidence from these empirical studies was insufficient with regards to if preservice teachers' self-efficacy in equitable science teaching and learning is influenced by their cultural awareness (though Cone's studies, [2009a, 2009b] indicated a positive relation). In addition, the factors influencing their cultural awareness were also inconclusive; the exception is having cross-cultural experiences. Therefore, it is important to determine how these two constructs are related and what factors moderate the relationship, in order to better prepare early childhood preservice teachers to provide fair opportunities to learn science to all of their students.

CHAPTER 3

METHOD

Introduction

The purpose of this study was to examine the relationship between early childhood preservice teachers' cultural awareness and their self-efficacy in equitable science teaching and learning. It further aimed to determine if the relationship between these two constructs was moderated by their ethnicity/race or language. Lastly, it sought to identify preservice teachers' understanding of equity in science education, as well as how they planned to incorporate the concept of equity into their future science teaching practices for linguistically, racially/ethnically, socioeconomically, and culturally diverse learners in early childhood classrooms.

This chapter addresses the following: (a) research design, (b) data collection methods, and (c) procedures including data collection as well as analytic methods for both quantitative and qualitative research questions. The former includes factor analysis, multiple regression, and hierarchical multiple regression to answer Research Questions 1 and 2. The latter includes thematic analysis answering Research Questions 3 and 4.

Research Design

For this study, an embedded mixed-methods research design was adopted as shown in Figure 1. According to Creswell and Plano-Clark (2011), by using the embedded research design, the findings from a quantitative analysis could be enhanced by the results of a qualitative investigation. Having the qualitative data embedded within a quantitative design, the current study tried to gain sufficient explanation of how cultural diversity awareness was related to preservice teachers' self-efficacy beliefs about equitable teaching and learning for diverse learners from the qualitative research approach.

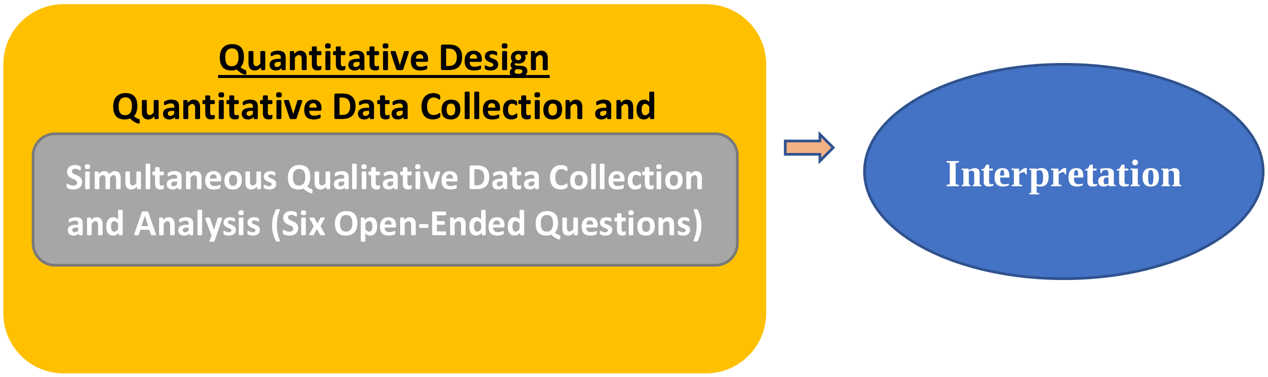

Figure 1. Embedded mixed methods research design.

Participants

Data for this study were drawn from 380 preservice teachers (*N* = 380) who self-enrolled in a science methods course in the fall of 2013, spring of 2014, fall of 2015, or spring of 2017 as part of a teacher preparation program at a state university in Texas. All participants were seniors seeking certification in early childhood through sixth grade education. As shown in Table 1 below, the participants consisted of 365 females (96.1%) and 15 males (3.9%). The racial/ethnic composition was as follows: 245 Caucasians (70.80%), nine African Americans (6.57%), 17 Hispanics (12.40%), seven Asian Americans (5.10%), and five multi-racial participants (3.65%). Two participants responded as "other" (1.46%). In terms of use of language, 302 participants (79.5%) spoke one language, 73 participants (19.2%) were bilingual, and one participant was trilingual (0.3%). Four participants (1.1%) did not respond. The age range of participants was 18 to more than 29 years. Respondents between the ages of 22 and 24 were the largest age group of the participants (51.8%).

Table 1

Demographic Characteristics of Participants

Variable		*n*	Percentage
Gender			
	Male	15	3.9%
	Female	365	96.1%
Age			
	18-21	106	27.9%
	22-24	197	51.8%
	25-28	42	11.1%
	29+	35	9.2%
Race/Ethnicity			
	African/African American	23	6.1%
	Asian/Pacific Islander	14	3.7%
	Caucasian	245	64.5%
	Latino/Hispanic	78	20.5%
	American Indian	2	0.5%
	Multi-Races	12	3.2%
	Other	5	1.3%
	No Response	1	0.3%
Language			
	Monolingual	302	79.5%
	Bilingual	73	19.2%
	Trilingual	1	0.3%
	No Response	4	1.1%

Note. $N = 380$.

Research Context

The current study was contextualized within a science methods course in a teacher preparation program at a state university located in Texas. The program was accredited by the Council for the Accreditation of Educator Preparation (CAEP) and the Texas Education Agency (TEA). The science methods class was an exit course that participants were required to take as one of their final courses before commencing their student teaching. The goal of the class was to develop preservice teachers' ability to integrate science content knowledge, including the nature of science, with the pedagogical knowledge and skills necessary for designing and teaching science classes to all students in K-6 classrooms. Through the course, they were expected to learn the various ways of teaching science content to meet the needs of diverse learners.

All of the methods courses were designed according to the same format; this ensured that all participants were provided with an equal opportunity to learn the same content under the same standards. During the semester, participants gained pedagogical content knowledge via hands-on experiments addressing buoyancy, density, and dissolving. They also developed lesson plans in response to physical, life, and earth/space science using the 5E Learning Cycle format (Biological Sciences Curriculum Study, 2006). They were required to micro-teach one physical science scenario. Following the CAEP requirements, all participants' lesson plans needed to include language objectives for English Language Learners and modifications for English Language Learners and students with special needs.

While taking the science methods course, the participants were placed for two days a week in a local public-school classroom that partnered with this program for 14 weeks. During that time, while assisting mentor teachers in the classroom, they broadened and sharpened their teaching knowledge and skills.

Data Collection Methods

A survey was developed that included both quantitative and qualitative methods of data collection; it was comprised of four sections: (a) a demographics questionnaire, (b) Cultural Diversity Awareness Inventory, (c) Self-Efficacy Beliefs about Equitable Science Teaching and Learning instrument, and (d) set of 6 open-ended questions.

Demographics Questionnaire

The demographics questionnaire was included to gather information about participants' backgrounds. Four questions were designed to identify each respondent's age, gender, race/ethnicity, and number of languages used (see Appendix A).

Quantitative Section

Cultural Diversity Awareness Inventory

The Cultural Diversity Awareness Inventory (CDAI) was first developed in 1986 by Gertrude B. Henry of the Michigan Reading Association, and then revised in 1995. The purpose of the CDAI is to measure the level of cultural diversity awareness of inservice elementary teachers. The instrument includes 28 items, aligned according to three categories: (a) Curriculum and Communication, (b) Identifying Differences, and (c) Discomfort with Different Cultures. Participants are asked to respond to each of the items on a 5-point Likert-type scale (5 = *strongly agree*, 4 = *agree*, 3 = *neutral*, 2 = *disagree*, and 1 = *strongly disagree*). Also, 13 items are reverse-coded. The reliability of the overall instrument was .90, and the test-retest reliability was .66. Its content validity was tested by a panel of experts.

Larke (1990) revised this instrument by modifying the categories of the original instrument while retaining the items. All 28 items were categorized into five groups: (a) general cultural awareness, (b) culturally diverse family, (c) cross-cultural communication, (d) assessment, and (e) creating a multicultural learning environment using multicultural methods. This instrument has been employed by many educational researchers, including Brown (2004a, 2004b), Iwai (2013), Larke (1990), Majzub, Hashim, and Johannes (2011), Milner, Flowers, Moore, Moore, and Flowers (2003), and Russell and Russell (2014). The current research followed the instrument revised in Larke (1990).

Self-Efficacy Beliefs about Equitable Science Teaching and Learning

The Self-Efficacy Beliefs about Equitable Science Teaching and Learning (SEBEST) instrument was developed by Ritter, Boone, and Rubba in 2001. The SEBEST is a modified version of the Science Teaching Efficacy Belief Instrument-Preservice (STEBI-B) (Enochs & Riggs, 1990), which was developed based on Bandura's social cognitive theory (1977). The instrument assesses participants' self-efficacy beliefs about the equitable teaching and learning of science when working with students who are diverse in terms of language, gender, class, or race/ethnicity. It consists of 34 items; 17 are reverse-coded. Participants indicate the extent to which they agree or disagree with each statement on a 5-point Likert-type scale (5 = *strongly agree,* 4 = *agree*, 3 = *neutral,* 2 = *disagree,* and 1 = *strongly disagree*).

The items on the SEBEST instrument are aligned according to two categories: (a) personal science teaching efficacy (PSTE) and (b) science teaching outcome expectancy (STOE) (17 items per category). The PSTE subscale measures preservice teachers' perceptions of their ability to affect student outcomes, based on sociocultural factors such as race/ethnicity, gender, language, and SES (e.g., "I will be able to effectively monitor the science understanding of children who are English Language Learners"). The STOE subscale assesses preservice teachers' beliefs regarding if student outcomes could be positively affected by effective teaching, regardless of those students' sociocultural backgrounds (e.g., "Children who are English Language Learners can be successful in learning science if the teaching is effective").

The reliability of the overall instrument used in the original study (Ritter et al., 2001) was .87, with subscale reliabilities of .83 and .78 for PSTE and STOE, respectively. In addition, the construct validity of the instrument was examined using a Rasch analysis; the result was .81 for the STOE and .98 for the PSTE subscales. Cone also conducted many studies using the SEBEST instrument. The research examining 48 preservice teachers' self-efficacy beliefs revealed a reliability of .90 for the PSTE and .91 for the STOE subscales (2009b). Another study (Cone, 2009a) of 81 preservice teachers showed alpha coefficients of .87 for the PSTE and .81 for the STOE subscales. The reliability coefficients for the overall instrument and subscales in the aforementioned studies indicated that the SEBEST was reliable (Kline, 1999; Remmers, Gage, & Rummel, 1965). Based upon these validity and reliability statistics, it can be concluded that the SEBEST is a valid and reliable instrument for assessing preservice teachers' self-efficacy beliefs regarding equitable science teaching and learning.

Qualitative Section

A set of six open-ended questions were included in the participants' questionnaire. The six questions were adapted from Cone's (2006) dissertation study and required written responses. The participants were asked about their perceptions of how their future science teaching would relate to students' race/ethnicity, social class, language, and culture. They were also asked to provide definitions of equity in general and science education (see the questions listed in Analytic Methods for the Qualitative Research Questions).

Procedures

Data Collection

This study was conducted in accordance with the requirements of the Institutional Review Board (IRB) at the University of North Texas. Prior to commencement of the current study, the research application to use an existing dataset was reviewed and approved by the IRB for the Protection of Human Subjects. The questionnaire used to gather data included questions about participants' demographic information, the two scales (CDAI and SEBEST), and a set of open-ended inquiries. The questionnaire was administered on the first day of class. The participants were given approximately 45 minutes to complete the survey.

Analytic Methods for the Quantitative Research Questions (RQs)

> RQ 1. To what extent was early childhood preservice teachers' cultural diversity awareness related to their self-efficacy in equitable science teaching and learning?
>
> RQ 2. Did early childhood preservice teachers' race/ethnicity or the number of languages they speak moderate the relationship between their cultural diversity awareness and self-efficacy in equitable science teaching?

The analysis involved several steps. First, all items in the CDAI and SEBEST were examined to confirm if each was understandable. After this examination, three items from the CDAI (Items 19, 27, and 28) were deleted because their wording was vague or they might have caused confusion in participants. Subsequently, a descriptive analysis was conducted to examine the means and standard deviations of each item on both scales, as well as any missing data, using the Statistical Package for Social Sciences (SPSS; version 24) software program.

Handling Missing Data

To handle the missing data, the types of missingness must first be diagnosed. This is because depending on the relationships among the missing values, incomplete variables, and other variables in the dataset, methods for dealing with the issue differ; the correct handling of such missing data allows for researchers to obtain unbiased parameter estimates. In general, there are three types of missing data mechanisms (Little & Rubin, 1987; Rubin, 1976): missing completely at random (MCAR), missing at random (MAR), and missing not at random (MNAR). MCAR refers to the probability that the values missing have no relation to either the incomplete variables or the other variables in the dataset. MAR refers to the probability that the values missing are related to other variables, and not only to incomplete variables in the dataset. MNAR applies to cases that are neither MCAR nor MAR.

For this study, Little's (1988) MCAR test was employed as a missing data analysis technique. Little's MCAR test is a useful method to test the assumption for missingness completely at random in multivariate data. The result indicated that the missing cases were less than 2%, in a chi-square = 1590.600 (df = 1559, p = .283), meaning that the data were missing completely at random. Based on this result, the listwise deletion method was adopted to handle the missing data. Listwise deletion is a simple method that deletes a case from analysis if it has any missing data for one of the variables. To use listwise deletion, missing data should be assumed to be MCAR, and a very small portion (e.g., 5%) of the total (Graham & Hofer, 2000). By conducting a listwise deletion, the sample size was reduced from 380 cases to 354 cases (N = 354).

Confirmatory Factor Analysis

A confirmatory factor analysis (CFA) was conducted separately in R (version 3.3.3) to verify the construction and operationalization of the CDAI and SEBEST scales. The initial models had serious issues such as poor model fits, an unidentified model, and negative variances. Although several attempts were made to modify both models, the solutions for both scales were not interpretable in ways that related to their theories. Therefore, instead of running a CFA, exploratory factor analysis was utilized to revise the two scales.

Exploratory Factor Analysis and Reliability Test

An exploratory factor analysis (EFA) was conducted to revise the two scales. EFA is a data-driven method for identifying the number of factors and underlying relationships among the items associated with each factor (DeCoster, 1998). Many researchers have emphasized the importance of having a large enough sample size to run an EFA. According to the guideline provided by Comrey and Lee (1992), it is considered poor to have a sample size of 100, fair for 200, good for 300, very good for 500, and excellent for 1,000 or more. Others have recommend having a ratio of participants to variables to 3:1 or 6:1 (Arrindell & van der Ende, 1985; Cattell, 1978) and 10:1 (Nunnally, 1978, Velicer & Fava, 1998, Yong & Pearce, 2013). The sample size of 354 in the current study met the requirements for both a good sample size and the ratio for participants to variables to conduct an EFA.

Multiple methods were utilized to determine the number of factors to retain: the eigenvalue-greater-than-one rule, scree test, Minimum Average Partial (MAP) test, and Parallel Analysis (PA). First, Kaiser’s (1960) eigenvalue-greater-than-one rule was applied to retain the factors. At the same time, a scree plot visually representing the eigenvalues was examined for an elbow in the data where the difference in sequential eigenvalues of two factors became small, as proposed by Cattell (1966). Along with these two methods, Velicer’s (1976) MAP test and Horn’s (1965) PA were conducted, which are validated procedures for determining the number of factors or components to retain. The MAP test "involves a complete principal components analysis followed by the examination of a series of matrices of partial correlations" (Velicer, 1976, p. 397). In this test, factor retention is determined by the lowest average partial correlation of items. Conversely, PA generates the eigenvalues derived from actual data, as well as the means and percentiles of random data's eigenvalues, so that researchers can compare these values and determine how many factors they should retain. In general, only factors with eigenvalues greater than the means and percentiles of the random data are retained.

In terms of factor loadings, Stevens (2006) suggested using values of .4 or higher for an interpretative purpose, regardless of sample size. Costello and Osborne (2005) defined cross-loadings as items that load at .32 or higher on more than one factor. Based on these guidelines, problematic items, such as low-loading, cross-loading, and freestanding items, were eliminated. After eliminating the problematic items, the internal consistencies of the overall scales of the CDAI and SEBEST and their subscales were assessed by calculating the Cronbach's alpha coefficients. The results of the alpha coefficients were interpreted by comparing the cut-off value of .7, which is acceptable for psychological constructs (Kline, 1999). Along with the alpha coefficients, the descriptive statistics for both scales were reported.

Multiple Regression for Research Question 1

Multiple regression is an extension of simple linear regression. This analysis method was used because it is "eminently suited for analyzing collective and separate effects of two or more independent variables on a dependent variable" (Pedhazur, 1997, p. 3). For this study, two different multiple regression analyses were conducted to answer Research Question 1. The only difference between the two regressions was the dependent variable, because the SEBEST had two subscales measuring different constructs for self-efficacy. For this study, the mean score of each subscale in the two scales was used for all of the regressions.

Multivariate outliers were screened using two different methods: (a) Mahalanobis' distance and (b) standardized residuals. Mahalanobis' distance refers to the "distance of a case from the centroid of the remaining cases where the centroid is the point created at the intersection of the means of all the variables" (Tabachnick & Fidell, 2007, p. 74). Using Mahalanobis' distance, extreme outliers were eliminated first. As an additional method of screening outliers, a residual plot was also examined. According to Tabachnick and Fidell (2007), outliers are cases that have standardized residuals above 3.3 and below -3.3 when the sample size is lower than 1,000. Based on this criterion, additional outliers were eliminated.

Hierarchical Multiple Regression for Research Question 2

A two-stage hierarchical (also called sequential) multiple regression (HMR) was conducted as a main analysis method to answer Research Question 2. HMR is a statistical method by which researchers are able to build up successive linear regression models by adding predictors (Tabachnick & Fidell, 2007). By comparing the models, it is possible to identify the effects of the predictors on a dependent variable.

Prior to conducting an HMR, all of the continuous independent variables (three subscales of the CDAI) were transformed by mean centering, a process that involves subtracting the mean of the variable from each participant's mean score on that variable (the mean of each case for Variable A – mean of Variable A) (Aiken & West, 1991; Cohen, Cohen, West, & Aiken, 2003). Categorical variables, which were considered potential moderators in this study, were dummy coded (Race/Ethnicity: 0 = White, 1 = Non-White; Language: 0 = Monolingual, 1 =

Multilingual). Cross-product terms, which are the same as interaction terms, were created by multiplying the mean centered variables by the dummy variables (Cohen, 1978). In terms of screening the data, multivariate outliers were identified and eliminated by following the same methods and procedure previously conducted for the multiple regression analysis; this resulted in a minor difference in sample size between regressions.

Analytic Methods for the Qualitative Research Questions

> RQ 3. How did early childhood preservice teachers conceptualize equity in science education?
>
> RQ 4. How did early childhood preservice teachers plan to incorporate equity in science education into their future science teaching practices for ethnically/racially, linguistically, culturally, and socioeconomically diverse learners in early childhood classrooms?

Thematic Analysis for Research Question 3

A thematic analysis was adopted as the main analytic method for the open-ended questions because this process is useful for identifying and analyzing patterns in qualitative data (Braun & Clarke, 2006). This method is theoretically flexible compared to other qualitative research methods in that its unique characteristics allow for easy comparison of the results to those of similar studies. Thus, it can be applicable within a wide range of theoretical frameworks, without conflict. In particular, this study used a data-driven thematic analysis approach to analyze participants' responses to the six questions on the questionnaire. This approach helps researchers validate their findings because in a data-driven approach, codes are developed in an inductive manner from the raw data; thus, they are highly sensitive to participants' responses (Boyatzis, 1998).

Trustworthiness is a term used in qualitative research as a substitute for validity. It supports the argument that it is “worth paying attention to” the inquirer’s findings (Lincoln & Guba, 1985). The trustworthiness of this study was ensured by providing frequency counts for the themes using Atlas.ti (version 8). The findings from the frequency analysis are reported in Chapter 4.

Six questions from Cone’s (2006) dissertation study were adapted to answer Research Questions 1 and 2. These six questions were as follows: (a) How, if at all, will your students’ racial/ethnic background affect your science teaching? (b) How, if at all, will your students’ social class affect your science teaching? (c) How, if at all, will your students’ language backgrounds affect your science teaching? (d) How, if at all, will your students’ cultural backgrounds affect your science teaching? (e) How would you define equity? and (f) How would you define equity in science education?

The participants’ responses to Questions (e) and (f) were used to answer Research Question 3. For the thematic analysis, these two questions were analyzed together because participants concisely defined equity in general and elaborated upon their definitions by applying them to science education. Three different codes were developed after reviewing the definitions of *equity in general* and *equity in science education*. For example, when participants defined equity in general or science education as providing support according to their students’ needs, the definition was coded as “access/support.” in terms of participants who described equity in general or in science education as being fair or impartial, their definitions were coded as “fairness.” When either was defined by using an equality concept such as sameness, the definition was coded as “Equality.”

Table 2

Five Patterns in the Definitions of Equity

Initial Patterns		Examples of Responses	
Equity in General	Equity in Science Ed	Equity in General	Equity in Science Ed
Access/Support	Access/Support	Equity is giving each student what they need to be successful. Students need different things to succeed, and when teachers provide students with various accommodations and/or modifications, they are creating an equitable education for their students.	I do not think that teaching science equitably is any different than teaching other subjects. Teachers must recognize the different needs of students and accommodate/modify accordingly. Education is not one size fits all.
		Equity is making sure all of the children are being treated equally by treating them differently.	Differentiating the lesson by accommodating it to fit the needs of each child.
Equality	Access/Support	Equity is when all people have the equal opportunity and access and right to achieve goals set for themselves or by others.	Equity when teaching science describes the effort put forth by the teacher to help students succeed. An equal amount of effort is not equity, some students require more.
		Everyone is equal.	We should teach the same to all students no matter where they come from. The only accommodations should be if it is something interfering with their learning such as learning disability, language barriers, etc. then accommodations will be made.

(table continues)

Initial Patterns		Examples of Responses	
Equity in General	Equity in Science Ed	Equity in General	Equity in Science Ed
Fairness	Access/Support	Equity is to be fair in regard to the situation and individual.	When teaching science, equity means providing every student with the instruction they specifically need to be successful in the classroom.
		Equity is the fair treatment of all students. It is making sure that every student is given the tools, guidance, and assistance they need to be successful. This means that not every student will get the same things.	When teaching science, equity means the same thing, giving every student what they need in order to be successful. Some students will need extra assistance. Some might need more hands-on experience while others prefer reading texts. Every child is different and the same thing doesn't work for everyone.
Fairness	Equality	Equity means being fair to all kinds of people even if they come from different backgrounds.	When teaching science, equity means giving the same opportunity to learn to everyone in your classroom.
		Simply, it means to be fair and impartial. Basically, no matter the student and their circumstances, they should be treated the same.	I think that it means that all students should be given the same opportunities in terms of science education.
Equality	Equality	Equity involves treating others equally regardless of their backgrounds.	You give students the same opportunity to learn and understand.
		Equity is treating all students equally and giving everyone the same chance to succeed in school. Equity is not favoring a specific race, culture, or language and treating everyone the same.	Equity in science means giving all the same opportunities to participate in experiments so everyone has the same learning experiences.

Note. For convenience, these patterns are denoted by Access/Support*Equity, Equality*Access/Support, Fairness*Access/Support, Fairness * Equality, and Equality * Equality.

From an initial thematic analysis of Research Question 3, five distinct patterns were identified from the participants' definitions of equity in general and equity in science education. They included patterns of *access/support* and *equity* (definition in general and definition for science education, respectively), *fairness* and *access/support*, *fairness* and *equality*, *equality* and *access/support*, and *equality* and *equality*. Table 2 presents examples of the participants' quotes in accordance with each pattern. Note that for convenience, these patterns are denoted by access/support*equity, equality*access/support, fairness*access/support, fairness*equality, and equality*equality.

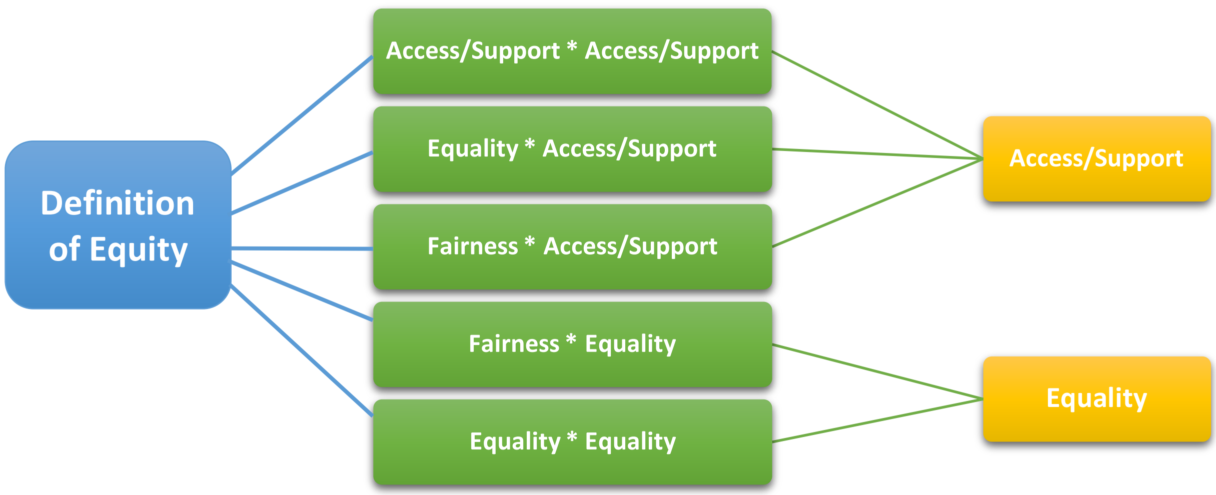

Figure 2. Finalized patterns of equity.

Subsequently, these five patterns were analyzed again. For the Fairness code, the meanings of "fair" and "impartial" were sometimes unclear, and were not identical across the responses because each participant had a different perception of their meanings. In this case, participants' definitions of equity in science education were taken into consideration when developing the themes because these definitions were regarded as their elaboration of their definitions of equity in general. The same protocol was applied to the participants who borrowed an "equality" concept to explain equity in general. After the analysis of the definitions of *equity* *in general* and *equity in science education*, these five patterns were combined into two: Equality and Access/Support (see Figure 2).

Thematic Analysis for Research Question 4

Another thematic analysis was conducted of participants' responses to questions (a), (b), (c), and (d) to answer Research Question 4. For example, if participants responded that their future students' language and socioeconomic backgrounds would affect their science instruction, the responses were coded as "equitable teaching." After finishing the coding for all cases, the number of items coded "equitable teaching" was compared among the four questions, in order to determine what student backgrounds the participants would consider the most and least important for advocating equity in science education. After determining these patterns, a thematic analysis was again conducted within each of two themes.

CHAPTER 4

RESULTS

Introduction

In this chapter, the both quantitative and qualitative results are presented in relation to the four research questions. Reporting of the analyses includes EFA, MR, and HMR in the quantitative research part. The process of screening multivariate outliers is also presented. For the qualitative research part, the results are illustrated based on the study's primary method, thematic analysis. In particular, the patterns found from the thematic analysis are emphasized.

Quantitative Results

Results of the Exploratory Factor Analyses

CDAI

Initially, an EFA using a principal component analysis (PCA) method with a promax (oblique) rotation was conducted with 25 items to determine the factor structures and examine the relationships among the factors. Results indicated that eight factors explained approximately 55.83% of the variance for the entire set of variables. The factor correlation matrix indicated that the highest correlation between factors was .36, meaning that all factors shared approximately 13% of the variance. According to Tabachnick and Fiddell (2007), if correlations are greater than .32, it would be reasonable to select an oblique rotation. However, in this study, a varimax (orthogonal) rotation was selected because only one out of 28 correlations exceeded .32. From this initial EFA, the scree test and PA both indicated a three-factor solution, and the MAP test recommended a two-factor solution. First, following the two-factor solution of the MAP test, an

EFA using a varimax rotation was conducted; however, the result was not interpretable because the items did not behave properly.

As a second option suggested by the scree test and PA, a three-factor EFA using a varimax rotation was conducted. These three factors accounted for approximately 32.13% of the variance for the entire set of variables. By looking at the pattern coefficients and communality coefficients, a total of eight items (Items 1, 6, 8, 13, 14, 15, 21, and 22) were eliminated because they failed to meet the minimum criteria of having loadings of .4 or above on a primary factor and no crossloadings of .32 or above on more than one factor.

For the final stage, 17 items remaining on the CDAI were factor analyzed using the PCA method with a varimax rotation. Although the varimax rotation was used, small correlations (approximately 11% of the shared variance) among the three factors were observed. The correlations between the factors are presented in Table 3.

Table 3

Factor Correlation Matrix

Factor	1	2	3
1	1.00	.20	.11
2	.20	1.00	.34
3	.11	.34	1.00

Note. N = 354.

The analysis indicated that three factors explained a total of approximately 40.69% of the variance for the entire set of variables. All 17 items in this analysis had primary loadings over .4. Further information about the factor loading for this final solution is presented in Table 4.

Table 4

Varimax-Rotated Factor Matrix for the CDAI

Item	Factors 1	2	3	h^2
7. other than the required school activities, my interactions with parents should include social events, meeting in public, places (e.g., shopping centers), or telephone conversations.	**.48**	-.10	-.10	.25
9. the family's views of school and society should be included in the school's yearly program planning.	**.68**	-.09	-.11	.48
10. it is necessary to include on-going parent input in program planning.	**.69**	-.02	-.07	.48
23. it is my responsibility to provide opportunities for children to share cultural differences in foods, dress, family life, and/or beliefs.	**.53**	.28	.15	.38
24. Individualized Education Program meetings or program planning should be scheduled for the convenience of the parent.	**.52**	.19	.07	.31
25. I make adaptations in programming to accommodate the different cultures as my enrollment changes.	**.59**	.06	.19	.39
26. the displays and frequently used materials within my setting show at least three different ethnic groups or customs.	**.50**	.13	.17	.29
12. the solution to communication problems of certain ethnic groups is the child's own responsibility.*	.11	**.68**	.22	.52
16. in a society with as many racial groups as the USA, I would expect and accept the use of ethnic jokes or phrases by some children.*	.06	**.73**	.10	.55
17. that there are times when racial statements should be ignored.*	.09	**.73**	.02	.54
18. a child should be referred for testing if learning difficulties appear to be due to cultural differences and/or language.*	-.08	**.48**	.26	.30

(table continues)

Item	Factors			
	1	2	3	h^2
20. translating a standardized achievement or intelligence test to the child's dominant language gives the child an added advantage and does not allow for peer comparison.*	.05	**.44**	.20	.24
2. it is important to identify immediately the ethnic group of the children I serve.	.28	.08	**-.49**	.32
3. I would prefer to work with children and parents whose cultures are similar to mine.*	.14	.14	**.66**	.48
4. I would be uncomfortable in settings with people who speak non-standard English.*	.16	.03	**.70**	.51
5. I am uncomfortable in settings with people who exhibit values or beliefs different from my own.*	.01	.22	**.66**	.48
11. I sometimes experience frustration when conducting conferences with parents whose culture is different from my own.*	.07	.29	**.54**	.38

Note. N = 354. Factor loadings greater than |.40| are shown in boldface. Items with an asterisk were reversely coded.

The subscales of this final solution did not match the subscales that either the developer revised version or Larke suggested. Therefore, these three factors were re-labeled based on the shared characteristics of the items under each factor. Factor 1 was labeled Creating a Multicultural Environment and Instruction (CMEI) due to the items, which were related to: interaction with diverse families to get them involved in curriculum planning, support for the learning of students from diverse backgrounds, and integration of diverse cultures into the classroom environment. This first factor explained approximately 14.54% of the variance. The second factor derived was labeled Insensitivity and Biases/Lack of Knowledge about Diversity (IBLKD); it accounted for approximately 13.33% of the variance. This factor was so-named because all of the items were associated with the insensitivity of ethnic jokes and bias/ignorance of racial statements and translated materials. The third factor was labeled Discomfort with Cultural and Linguistic Diversity (DCLD) because the items were related to discomfort or frustration stemming from students and families whose cultures and languages were different from those of the teachers. The variance explained by this factor was approximately 12.83%. Item 2 was dropped from the final subscale of DCLD because its content did not conceptually fit.

The descriptive statistics for the three CDAI subscales and the results of the reliability test for the overall scale and subscales are shown in Table 5. The average score for participants' CMEI was 26.98 (*SD* = 3.28). The average scores were 19.98 for IBLKD (*SD* = 2.98) and 14.87 for DCLD (*SD* = 2.71). The internal consistency of the overall scale was .72, which was acceptable; however, the alpha coefficients of the subscales had marginal values.

Table 5

Summary of Descriptive Analysis and Reliability of the CDAI

	No. of Items	Mean (*SD*)	Skewness	Kurtosis	Cronbach's α
CMEI	7	26.98 (3.28)	-.10	-.13	.65
IBLKD	5	19.98 (2.98)	-.78	1.65	.64
DCLD	4	14.87 (2.71)	-.11	-.17	.67
Overall Scale					.72

Note. *N* = 354.

SEBEST

An initial EFA of the 34 items of the SEBEST was conducted using a PCA method with a promax rotation. Results showed that five factors accounted for approximately 58.91% of variance. Also, the highest correlation between factors was .68 (approximately 46% of the shared variance), which was reasonable for keeping the promax rotation (Tabachnick & Fidell, 2007). In determining the number of factors to retain, the scree plot suggested a two- or four-factor solution, while both the MAP test and PA suggested a four-factor solution. A four-factor-solution was first attempted, but the results were uninterpretable. In addition, tapping into its theoretical foundation, this scale was created based on Bandura's self-efficacy theory, which has two dimensions: self-efficacy expectancy and outcome expectancy. Therefore, a two-factor-solution was used for the rest of the procedures.

A principal components factor analysis of the 34 items using the promax rotation was conducted, with two factors explaining 46.13% of the variance. The correlation between Factors 1 and 2 was .57. At this stage, four items (Items 4, 7, 17, and 19) were eliminated because they were either crossloaded to both factors or loaded to factors with pattern coefficients less than .4. By repeating the same analysis, an additional two items (Items 5 and 27) were eliminated because of crossloading problems. Throughout the procedure, a total of six items were eliminated from the scale.

The 28 remaining items were factor analyzed using the PCA method with a promax rotation. Two factors explained 47.85% of the variance. The correlation between the two factors was .50. Although all 28 items in this analysis had primary loadings over .4, Factor 1 had mixed items related to both STOE and PSTE, whereas items in Factor 2 were aligned with PSTE. In order to align with Bandura's theory of self-efficacy, six items associated with PSTE in Factor 1 (Items 11, 15, 23, 29, 31, and 33) were eliminated so that Factor 1 consisted of items that measured participants' science teaching outcome expectancy.

A final factor analysis of the 22 items remaining was conducted using the PCA method with a promax rotation. The analysis yielded two factors explaining a total of approximately 48.47% of the variance for the entire set of variables. Factors 1 (STOE) and 2 (PSTE) accounted for 38.59% and 9.89% of the variance, respectively. The factor loading matrix for this solution is presented in Table 6. The correlation between the two factors was .46 (approximately 21% of the shared variance).

Table 6

Promax-Rotated Factor Matrix for the SEBEST

Item	Factor 1	Factor 2	h^2
1. I will be able to effectively teach science to children whose first language is not English.	-.15	**.67**	.38
2. Girls can learn science if they receive effective science instruction.	**.55**	-.13	.25
10. Effective science teaching can help children from low socioeconomic backgrounds overcome hurdles to become good science learners.	**.69**	-.01	.47
16. Children of color can succeed in science when proven science teaching strategies are employed.	**.67**	-.19	.37
20. Girls have the ability to compete academically with boys in science when they receive quality science instruction.	**.76**	-.16	.50
24. A good science teacher can help children from impoverished backgrounds achieve in science at the same level as children from higher socioeconomic backgrounds.	**.73**	.03	.55
25. I will be able to effectively monitor the science understanding of children who are English Language Learners.	.30	**.52**	.50
26. Girls can develop in science at the same level as boys if they receive science instruction that is effective.	**.87**	-.17	.65
32. White children can learn science as well as other children when effective science teaching is employed.	**.78**	-.11	.55
34. Children who are English Language Learners can be successful in learning science if the teaching is effective.	**.85**	-.01	.72
3. I do not have the ability to teach science to children from economically disadvantaged backgrounds.*	.25	**.45**	.37
9. I do not know teaching strategies that will help children who are English Language Learners achieve in science.*	-.09	**.80**	.57
13. I do not know how to teach science concepts to children who speak English as a second language.*	-.03	**.84**	.69
21. I will not be able to teach science to children who speak English as a second language as effectively as I will to children who speak English as their first language.*	-.13	**.76**	.50

(table continues)

Item	Factor 1	Factor 2	h^2
6. Good teaching cannot help children from low socioeconomic backgrounds achieve in science.*	**.44**	.19	.30
8. Girls are not as capable as boys in learning science even when effective instruction is provided.*	**.56**	.00	.31
12. Some children of color cannot achieve in science.*	**.56**	.13	.40
14. Effective science teaching cannot improve the science achievement of children from impoverished backgrounds.*	**.61**	.16	.49
18. Children who speak English as a second language are not able to achieve in science even when the instruction is effective.*	**.64**	.15	.52
22. Children of color cannot learn science as well as other children even when effective science teaching instruction is provided.*	**.69**	.08	.54
28. Girls do not have the ability to learn science as well as boys, even when effective teaching techniques are used.*	**.72**	.07	.57
30. Children who are English Language Learners do not have the ability to be successful in science even when the science instruction is effective.*	**.59**	.18	.48

Note. N = 354. Factor loadings greater than |.40| are shown in boldface. Items with an asterisk were reversely coded.

As shown in Table 7, the average scores for STOE and PSTE on the SEBEST were 73.61 (SD = 6.93) and 24.00 (SD = 3.43), respectively. Internal consistency for the overall scale was .91. The Cronbach's alpha efficiencies for the STOE and PSTE subscales were .92 and .79, respectively.

Table 7

Summary of Descriptive Analysis and Reliability of the SEBEST

	No. of Items	Mean (SD)	Skewness	Kurtosis	Cronbach's α
STOE	16	73.61 (6.93)	-1.22	1.33	.92
PSTE	6	24.00 (3.43)	-.13	-.55	.79
Overall Scale	22				.91

Note. N = 354.

Results of Research Question 1

A multiple regression was utilized to investigate which CMEI, IBLKD, and DCLD on the CDAI predicted STOE or PSTE on the SEBEST. Since a multiple regression could not be run with more than one dependent variable, two independent regressions were conducted. First, the scores of items under each subscale in the CDAI and SEBEST were added up, and then their means were calculated. The mean score of each subscale was used for running not only a multiple regression, but also a hierarchical regression. As shown in Table 8, the mean scores for CMEI, IBLKD, and DCLD on the CDAI were the independent variables, while the mean scores for PSTE and STOE on the SEBEST were the dependent variables.

Table 8

Multiple Regressions

	Independent Variable	Dependent Variable
Multiple Regression 1	CMEI IBLKD DCLD	PSTE
Multiple Regression 2	CMEI IBLKD DCLD	STOE

Note. CMEI, IBLKD, DCLD, PSTE, and STOE: Mean scores of the variables

After running two multiple regressions, the extreme outliers that had values above 18.467 were deleted according to the criterion of Mahalanobis' distance at $p < .001$, $\chi^2(4) = 18.467$; the data were then saved. Subsequently, multiple regressions were again conducted. By examining the residuals plots of both regressions, outliers having standardized residuals lower than -3.3 were observed; these were then also deleted from the final datasets. Next, multiple regressions were conducted on these final datasets to identify which CMEI, IBLKD, and DCLD scores on the CDAI predicted STOE or PSTE scores on the SEBEST.

First, it was tested if the participants' scores for CMEI, IBLKD, and DCLD predicted the STOE scores. The overall model was statistically significant, $F(3, 346) = 43.965$, $p < .001$. CMEI, IBLKD, and DCLD accounted for approximately 28% ($R^2 = .28$) of the variance in STOE (see Table 3). The participants' CMEI and IBLKD scores statistically significantly predicted the STOE scores (β = .308, $p < .001$; β= .354, $p < .001$, respectively). As the values of the structure coefficients (r_s) in Table 9 indicate, CMEI, IBLKD, and DCLD were positively associated with STOE. IBLKD was the strongest predictor (β = .354, $r_s = .807$), followed by CMEI (β = .308, $r_s = .719$) and DCLD (β = .044, $r_s = .411$).

In addition, when PSTE scores were regressed on the scores of CMEI, IBLKD, and DCLD, the overall model was statistically significant, $F(3, 349) = 34.806$, $p < .001$. the variance in PSTE explained by CMEI, IBLKD, and DCLD was approximately 23% ($R^2 = .23$). All of the CMEI, IBLKD, and DCLD scores statistically significantly predicted the PSTE scores, and they were positively associated with the PSTE scores (β = .180, $p < .001$, $r_s = 550$; β = .209, $p < .001$, $r_s = .705$; β = .288, $p < .001$, $r_s = .811$, respectively). DCLD most-predicted PSTE (β = .288, $r_s = .811$), and followed by IBLKD and CMEI (β = .209, $r_s = .705$; β = .180, $r_s = 550$, respectively.

Table 9

Summary of Multiple Regressions of CMEI, IBLKD, and DCLD Predicting STOE and PSTE

Variables		STOE				PSTE			
		b	β	*t*	r_s	*b*	β	*t*	r_s
CMEI		.274	.308	6.587***	.719**	.220	.180	3.760***	.550**
IBLKD		.252	.354	7.214***	.807**	.206	.209	4.151***	.705**
DCLD		.027	.044	.888	.411**	.245	.288	5.723***	.811**
STOE	*N*	350							
	R^2	.276							
PSTE	*N*	353							
	R^2	.230							

Note. $p < .05$*, $p < .01$**, $p < .001$***

In short, the results showed that the CMEI and IBLKD scores were statistically significant predictors for the STOE scores, and the CMEI, IBLKD, and DCLD scores were statistically significant predictors for the PSTE scores. However, these results should be interpreted with caution because, by conducting the EFAs, the two measures were substantially revised (i.e., items deleted and subscales redefined), which could have compromised their validity. Consequently, these results were inconclusive.

Results of Research Question 2

A two-stage hierarchical multiple regression (HMR) was conducted to identify potential interaction effects between the CDAI and participants' demographic characteristics (race/ethnicity and the number of languages they speak) on predicting the SEBEST. For example, as shown in Table 10, two sequential regression models were created. The only difference between the two models was the inclusion of an interaction term between each subscale of the CDAI and the potential moderators. In this way, a total of 12 hieratical multiple regression models were created. The significance of the interaction effect was determined by looking at the increase in effect size (R^2) with the corresponding p value in each HMR.

As regards the outliers, the same methods and procedure conducted earlier were employed to screen multivariate outliers in each HMR. Extreme multivariate outliers were identified and deleted using the criterion of the Mahalanobis' distance at $p < .001$, $\chi^2(4) = 18.467$. With the new dataset, the HMR was conducted again. The residuals plot of each regression was then examined to identify the outlying cases. Cases having standardized residuals lower than -3.3 were identified from each HMR and deleted from the final datasets. Then, final HMRs were conducted from these final datasets.

Table 10

Examples of Hierarchical Multiple Regressions

		Independent Variable	Dependent Variable
1	Model 1	CMEI Race/Ethnicity	PSTE
	Model 2	CMEI by Race/Ethnicity	
2	Model 1	CMEI Language	PSTE
	Model 2	CMEI by Language	
3	Model 1	CMEI Race/Ethnicity	STOE
	Model 2	CMEI by Race/Ethnicity	
4	Model 1	CMEI Language	STOE
	Model 2	CMEI by Language	

To test for a possible interaction between Race/Ethnicity and CMEI scores in predicting the STOE scores, the STOE scores were first regressed on Race/Ethnicity (Coding: 0 = White, 1 = Non-White) and the centered CMEI scores. As presented in Table 11, the variables of Race/Ethnicity and CMEI accounted for approximately 14% ($R^2 = .14$) of the variance in STOE, $F(2, 346) = 28.641$, $p < .001$. In the second step, the interaction term (CMEI by Race/Ethnicity) was added to the equation. The addition of this interaction term explained an additional 1% of the variance ($\Delta R^2 = .01$) in STOE; this change in R^2 was statistically significant, $F(1, 345) = 5.485$, $p < .05$, meaning that the interaction between Race/Ethnicity and CMEI was statistically significant. That is, the CMEI scores had a statistically significant differential effect on the STOE of White participants, as compared to non-White participants.

Table 11

Summary of HMR Analysis for CMEI with an Interaction Effect of Race/Ethnicity Predicting STOE

Predictor	Intercept	R^2	b	SE B	β	r_s
Model 1	4.606	.14				
CMEI			.341	.045	.379***	.998**
Race/Ethnicity			.021	.044	.024	-.044
Model 2	4.604	.16				
CMEI			.409	.053	.454***	.954**
Race/Ethnicity			.013	.044	.015	-.042
CMEI by Race/Ethnicity			-.230	.098	-.139*	.275**
ΔR^2		.013				
F for change in R^2		5.485*				

Note. N = 349. p < .05*, p < .01**, p < .001***

Given the statistically significant interaction, separate regressions were conducted to determine if the CMEI scores were a statistically significant predictor for both White and non-White participants. The CMEI was regressed on the STOE of White participants. As presented in Table 12, the CMEI accounted for approximately 20% (R^2 = .20) of the variance in STOE, F(1, 230) = 56.889, p < .001. When the CMEI was regressed on the STOE of non-White participants, the variance explained was approximately 4% (R^2 = .04), F(1, 115) = 5.017, p < .05. The result indicated that when every unit in the CMEI was increased, White participants' STOE scores were .228 higher than those of non-White participants. For a visual comparison between White and non-White participants, Figure 3 provides the regression lines.

Table 12

Summary of Linear Regression Analyses for CMEI Predicting STOE for Two Groups

Participants	n	R^2	b	β	t	r_s
White	232	.198	.409	.445	7.542***	1.000**
Non-White	119	.042	.179	.204	2.240*	.204*

Note. p < .05*, p < .01**, p < .001***

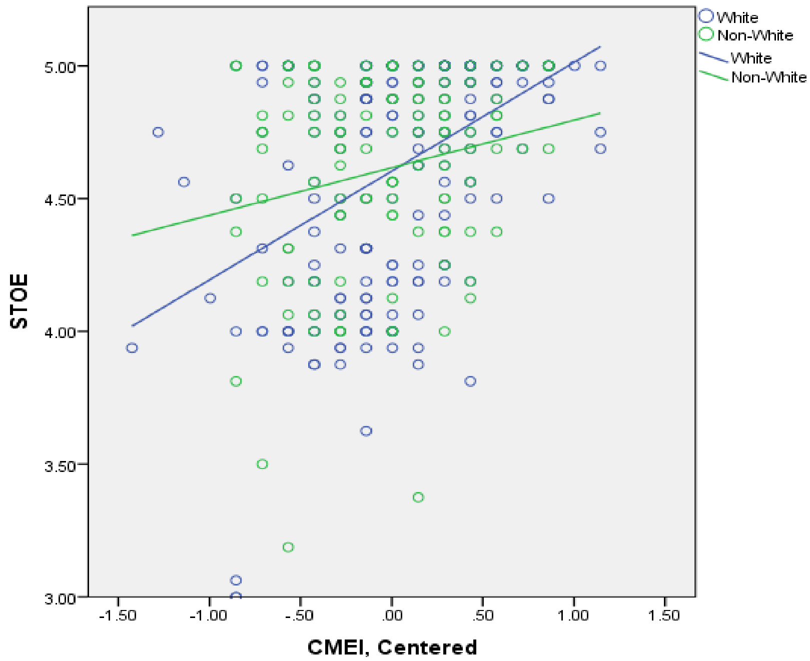

Figure 3. Plot of the regression lines for White and non-White participants.

Overall, Race/Ethnicity moderated the relationship between the CMEI and STOE. Also, the CMEI was a statistically significant predictor for both White and non-White participants. The effect of the CMEI on non-White participants in predicting the STOE was minimal comparing to White participants when looking at the R^2, β, and r_s values of the both groups. However, bearing in mind that the validity issues for the two instruments discussed above, these results should be interpreted with caution.

The results showed an interaction effect only between Race/Ethnicity and the STOE. However, by examining other HMRs, it seemed that language might be a potential predictor that may have a statistically significant relationship with PSTE. The *p*-values, β weights, and structure coefficients (r_s) of Language listed in Table 13 provide the rationale for this assumption. Therefore, a further analysis to examine this assumption was conducted.

Table 13

Summary of HMR Analyses for CMEI with the Interaction Effects of Language Predicting PSTE

HMR	Variables	Intercept	R^2	b	SE B	β	r_s
1 N = 348	Model 1	3.944	.104				
	CMEI			.349	.063	.282***	.832**
	Language			.269	.076	.180***	.493**
	Model 2	3.949	.111				
	CMEI			.313	.067	.253***	.930**
	Language			.290	.077	.194***	.136*
	CMEI by Language			.336	.205	.090	.273**
	ΔR^2		.007				
	F for change in R^2		2.700				
2 N = 349	Model 1	3.944	.158				
	IBLKD			.368	.051	.354***	.901**
	Language			.257	.073	.173**	.458**
	Model 2	3.944	.158				
	IBLKD			.366	.056	.351***	.976**
	Language			.256	.074	.172**	.097
	IBLKD by Language			.016	.146	.006	.397**
	ΔR^2		.000				
	F for change in R^2		.012				
3 N = 349	Model 1	3.956	.173				
	DCLD			.318	.043	.367***	.928**
	Language			.233	.074	.156**	.482**
	Model 2	3.956	.175				
	DCLD			.336	.047	.388***	.337**
	Language			.249	.076	.167**	.458**
	DCLD by Language			-.103	.113	-.051	.205**
	ΔR^2		.002				
	F for change in R^2		.827				

Note. $P < .05^*$, $p < .01^{**}$, $p < .001^{***}$

The PSTE scores were regressed on Language and the CMEI, IBLKD, and DCLD scores. These four variables explained approximately 26% (R^2 = .26) of the variance in PSTE, $F(4, 348)$

= 30.977, $p < .001$. Although Language was not the strongest among the four variables, it was a statistically significant predictor ($\beta = .181$, $r_s = .353$, $p < .001$). The results showed that DCLD predicted the most ($\beta = .271$, $r_s = .759$), followed by IBLKD, CMEI, and Language with a positive direction (see Table 14). This result indicated that if participants spoke more than one language, they were more likely to have a higher sense of personal science teaching efficacy. Recalling the validity issues affecting the two instruments, this result also should be taken with caution.

Table 14

Summary of Multiple Regression of Language, CMEI, IBLKD, and DCLD Predicting PSTE

	b	β	t	r_s
Language	.265	.181	3.903***	.353**
CMEI	.239	.196	4.149***	.515**
IBLKD	.212	.216	4.365***	.660**
DCLD	.230	.271	5.470***	.759**

Note. $N = 353$, $p < .05$*, $p < .01$**, $p < .001$***

Qualitative Results

After completing the thematic analysis described in the Methods section, three predominant themes related to participants' conceptualization of equity in science education were identified. First, the participants harbored alternative understandings of the definitions of equity, both in general and in science education. They also conceptualized equity in science education as an issue independent of their future students' racial/ethnic backgrounds, and instead as a subject associated with their students' English proficiency.

Research Question 3

Alternative Conceptions: Equity in Science Education

The results of the thematic analysis of the data revealed that participants in this study held alternative conceptions about equity in science education. Participants' alternative conceptions were characterized by two distinct patterns: (a) one group conceived of equity as equality, and (b) the other group conceived of equity as providing appropriate access and support based on students' needs.

Nearly one third (n = 125, 32.98%) of the total participants conceptualized equity as treating all students the same, and providing identical teaching services and resources for learning science regardless of students' backgrounds. The participants interchangeably used the equality concept for describing equity in general and equity in science education, as demonstrated in Table 15. They asserted that all students were capable of learning science, teachers should not hold "biases" or rely on "stereotypes" regarding certain students' backgrounds, and they should "not judge" students' abilities based on their backgrounds. For these participants, offering different types of treatment and additional support only to particular students was regarded as "discrimination" or "favoritism/preference." With conviction, these participants explained that it was necessary for teachers to provide the same academic conditions (such as instructions, resources, levels of respect, and types of expectations) to all students. Therefore, they believed that they would design everything the same for all of their future students, regardless of background, in order for all students to receive equal opportunities to learn science.

Table 15

Examples of Two Patterns in the Definitions of Equity in Science Education

Pattern	Definition
Equality	• Equity means that all children from all backgrounds, cultures, races, etc. have the right to learn and they are to be offered the same education as everyone else. I believe that equity in science teaching means all students have the right to the same nonbiased content and they are to be given the same materials and opportunities as everyone else.
	• Equity to me is being equal to all my students and providing the same opportunities for all to learn and grow. Equity in science means to give everyone the chance they deserve and have equal access to your teaching and resources.
	• Equity is being fair. If classroom rules are set, they must be followed with no exceptions. If the teacher is lenient with one student, they should be lenient with the rest of the classroom as well. Treating the students equally and with the same respects help them feel safe in the classroom environment. That promotes student's participation in the classroom. When teaching science, the definition of equity remains the same. It means that every child should be treated equally and not feel discriminated. The students should all learn the same material, use the same equipment, and receive the same assistance from the teacher.
	• I would define equity as each child receiving equal amount of materials, expectations, and curriculum openness (not teaching towards one individual student). Equity in teaching science means giving each child equal amounts of materials, expectations, and curriculum openness.
	• To me, equity means equal opportunity for everyone (for men and women without bias towards their social standing, academic opinions, or ethnicity). Science does not depend on any of those things - it depends on experimentation and discovery of new facts. Science is an objective subject, in which one must prove what they know to be true.

(table continues)

Pattern	Definition
Access & Support Based on the Level of Needs	• Equity is giving each student an equal opportunity to learn. Different students will require varying levels of help and adjustments in order to make the learning opportunity equal. You cannot just give everyone the same thing and expect the students to be on the same level you have to adjust to the individual student to get them there. Equity in science is to adjust the lessons and the materials individually to the students so that they all have the equal opportunity to learn.
	• Equity differs from equality. All students don't need the exact same thing (equality). They need the tools for them as individuals (Equity). Equity in science education means to applying different teaching styles and materials who may need more or less help.
	• Equity is about being equal to all but providing the necessary accommodations to the students that need it. Some students might need more help in certain areas to get them where the other kids in the class are. So as a teacher you have to give them that extra push to have them at the same level. When teaching science, equity means to make sure that all the students are on the same levels and help certain students when needed.
	• Equity means that a teacher provides different options and uses different strategies/ techniques/ accommodations, in order to provide equal opportunity for all his/her students. Equity in science means meeting all of your students where that are at, in terms of their current knowledge and understanding, then providing specific strategies and accommodations to get their knowledge to where it needs to be.
	• I would define equity as each person getting the resources they need to level the playing field and succeed. Equity is different from equality (in my opinion) because equality is everyone getting the same resources (regardless of necessity), and equity is everyone potentially getting the resources they need, and ultimately getting access to the resources they need to succeed at the same opportunity as everyone else. When teaching science, equity would mean providing certain supports and resources to some students who may need it, but not necessarily providing them to everyone. For example, if a student needed visual supports or linguistic resources, they would be able to have access to those things during the lesson or experiment in order to have the same learning experience as students who may not need those supports.

Another one third (*n* = 124, 32.63%) of the total participants conceptualized equity as providing appropriate access and support based on the levels of students' needs. As shown in Table 15, the participants distinguished equality from equity by arguing that not all students required the same help/support from teachers to learn science, and depending on the specific needs of each student, teachers needed to provide pertinent accommodations. The participants further explained that when teachers were able to meet the different needs of their students, equal opportunity to learn science for all students could be ensured. This viewpoint was remarkably different in that those who defined equity by using the equality concept considered treating/teaching students differently as "discrimination" or "favoritism/preference."

The data also showed that a few participants acknowledged the unique backgrounds of students, such as their different learning styles, disabilities, and language abilities, as factors that might be influential on their ability to learn science. They commented that they would try to ensure that students with those types of backgrounds would receive equitable learning opportunities. However, students' differences in terms of race/ethnicity, socioeconomic status, and culture were not considered to be matters that might impact students' learning or require the provision of additional instructional help/support.

Results of the Frequency Analysis

The saliency of the claim that participants held alternative beliefs regarding equity in general as well as in science education was supported by the findings of the frequency analysis that addressed their definitions of both. Groups of words related to these alternative concepts – equity as providing appropriate access and support based on the levels of students' needs and equity as equality – were highly ranked in the frequency analysis results (Appendix C). Of the total 3,943 words referring to participants' definitions of equity in general, the most recurring word group was *equity*-related words (e.g., *equity/equitable, fair/fairness/fairly, impartial, unbiased*, and *justice*; word count: 232, 5.88%). Following were *equality*-related words (e.g., *equal/equality/equally/equals* and *same*; word count: 221, 5.61%), *need*-related words (e.g., *need/s, require/s*; word count: 77, 1.95%), *opportunity*-related words (e.g., *opportunity/opportunities, chance/s*; word count: 66, 1.67%), and *treat*-related words (*treat/treated/treating/treatment*; word count: 60, 1.52%) and *help*-related words (e.g., *help/helping, support/supporting, assistance, scaffolding, adjust/adjustments, adaptation/s, alter, modifications/modifying*, *accommodations/accommodating/accommodated*, and *differentiation*; word count: 59, 1.49%). These recurring word groups were aligned with the participants' two definitions of equity in general.

Similar results were found from the frequency analysis of the definition of equity in science education (Appendix C). Word groups were found that related to two patterns of defining equity in science education. Of the total 4,703 words in the definitions of equity in science education, *equality*-related words (e.g., *equal/equality/equally/equals* and *same*; word count: 137, 2.91%) were the most often recurring. Following were *help*-related words (e.g., *help/helping/helped, support/supports/supporting, scaffold/scaffolding, modify/modifications/modifying, adjust/adjusting, differentiated/differentiation/differentiating, alter/altered, adapting/adaptions/adaptation/adaptations*, and *accommodate/accommodations/accommodating*; word count: 107, 2.27%), *need*-related words (e.g., *need/needs/needed, require/requires/required*, and *necessary/necessarily;* word count: 95, 2.02%), and *equity*-related words (e.g., *equity/equitable/equitably, fair/fairly/fairness, impartial*, and *nonbiased*; word count: 94, 2.00%).

Research Question 4

Beyond Students' Racial/Ethnic Backgrounds

Participants predominantly believed that equity in science education was not dependent on their future students' racial/ethnic backgrounds because race/ethnicity did not affect learning ability. They argued that because their future students would be fully capable of learning science content no matter what their racial/ethnic background is, they would all learn in the same way and would not need accommodations from teachers. The quotes in Table 16 exemplify the participants' beliefs about equity in science education in relation to students' racial/ethnic backgrounds. They claimed that they would not alter their science instruction for students from any particular racial/ethnic group and would instead give the same opportunities to all, exemplifying a "one size fits all" approach to science instruction.

Table 16

Students' Racial/Ethnic Backgrounds in Relation to Equity in Science Education

Responses
I do not think my students' racial backgrounds will affect my science teaching. I try to treat all students the same no matter what their ethnic background is.
Students will be students regardless of their backgrounds.
Racial and ethnic backgrounds will absolutely not affect my science teaching. Each child has an opportunity to learn REGARDLESS of their background and ESPECIALLY REGARDLESS OF THEIR COLOR. I cannot stress enough how appalled I am that I am actually answering this question right now. My true feeling is that ALL CHILDREN HAVE THE OPPORTUNITY TO LEARN. It is my responsibility to facilitate this opportunity to ALL OF MY STUDENTS without discrimination. I should not notice a "coincidence" in my "Black students" or my "White students" all doing a certain way in a certain subject.
First of all, it should not matter the color of a student's skin or their background. I know for a fact no matter the color of their skin or their ethnic background anyone and everyone can learn and it will not affect my science teaching because I am teaching my students not teaching myself.
It does not matter is your child is male or female. Black, white, brown, yellow, or purple! People should not have to let stereotyping dictate how they are going to treat/teach a student. If a student needs more help it is not because of their race or gender! You help a student because they are your student and you want them to succeed.

(table continues)

Responses
I do not feel that a student’s race background affects my ability to teach science in any way. There will be students with strengths and weakness in science across every racial group.
There will always be those who don’t quite understand the subject.

The data further revealed that participants supported this belief regarding not changing science instruction with rationales such as: (a) subscribing to the notion of the universality of science, and (b) adopting a colorblind approach/policy for equity in science education. First, some participants claimed that students’ racial/ethnic backgrounds were not a matter that affected equity in science education because science was universal (see Table 17). From their perspective, science was a set of knowledge with empirical evidence, and thus it would be the same for all. This belief leant itself to the desire to teach students from diverse racial/ethnic backgrounds without making instructional accommodations.

Along with this belief about the universality of science, adopting a colorblind approach/policy was described as an appropriate and desirable means of advocating equity in learning for racially/ethnically diverse students in science education. As presented in Table 17, the participants denied linking students’ learning differences to their racial/ethnic backgrounds. Identifying racial/ethnic differences in learning and then providing appropriately differentiated instruction was a sensitive process that engendered discomfort in these future teachers. They regarded the process itself as discrimination, a violation of equity, or even racism. The participants’ discomfort was evidenced from their responses, such as: “How would someone else's race affect the way I teach?!” “Why is that ever up for debate?” and “Are teachers blaming ethnic backgrounds on low science scores?”

In this regard, a key determinant for these participants was not students’ racial/ethnic backgrounds, but certain of their inner aspects (see Table 17). These inner aspects, according to the participants, referred to personal characteristics and interests, learning style, willingness to study, and level of ability. Participants believed that these individual differences played a pivotal role in determining students' different levels of science achievement.

Table 17

Participants' Responses by Viewpoint

	Responses
Universality of Science	Growing up overseas has helped me learn to be able to work with diverse groups of people. I believe science has no borders and that racial/ethnic backgrounds shouldn't change the way I teach science
	I do not believe that my racial and ethnic background affect my science teaching. Creating a lesson plan is based on TEKS and not the teachers background. I believe that the teachers beliefs do not influence what is taught in the class because a teacher has teaching standards to meet.
	I'm honestly not sure if that is an issue, other than the idea that some may be uncomfortable. I am uneducated in this area, but other than a person's religion deeming some materials inappropriate, I truly believe science is science and can be explained and learned by all races and genders/sexes. I will cater examples and materials to their understanding and background.
	I think science is universal and backgrounds won't have much of an effect.
Colorblind Approach/Policy	I will view each student as an equal, and I will be colorblind to their race.
	They have not affected my teaching. I see students not skin color.
	It should not affect my teaching at all. Color is not an issue to me, everyone learn at different levels and times, has the ability no matter the color.
	I do not believe that a student's racial/ethnic background will affect my science teaching. I don't care what race the children in my classroom are, to me they are all the same.
Students' Inner Aspects	It does not affect my teaching at all. I believe color does not affect how a person learns. It is their ability and their willingness that really tell me if they want to be there.
	Not at all. Their learning styles will affect the way I teach.
	I want to focus on the student's character and learning styles rather than their race or ethnic backgrounds.

In short, the predominant conceptualization among the participants was that equity in science education did not relate to students' races/ethnicities. The participants insisted that because this element of their backgrounds would not affect their students' ability to learn science, there would be no need to tailor their science instruction to students' various races/ethnicities. Believing in the universality of science made the participants deeply committed to this belief. Instead of focusing on racial/ethnic background, participants claimed that equity for all in science instruction would be ensured if teachers took into consideration their students' various inner aspects. They also believed that by adopting this approach/policy, they would not be judged as unfair and/or be labelled as perpetuating stereotypes.

Results of the Frequency Analysis

The frequency analysis of recurring words in the participants' responses to the question of how students' racial/ethnic backgrounds might affect their future science teaching supported the participants' belief that equity in science education was not related to students' racial/ethnic backgrounds. Of the total 6,206 words that comprised the participants' responses, the words *not*, *no*, *none*, and *never* (word count: 199, 3.21%) recurred the most.

Insufficient English Proficiency as a Barrier

Participants predominantly believed that equity in science education was related to students' English proficiency. They assumed that students speaking languages other than English would need to receive additional support to understand and develop scientific knowledge and skills. The participants shared specific examples of accommodation methods and strategies for English Language Learners (ELLs) that would ensure equity in their learning of science. The examples included integrating methods and strategies such as slow speech, repetition, partner work, pre-teaching, and the SIOP model into their science lessons. Other examples included utilizing two- or three-dimensional visual aids such as word walls, notecards, graphic organizers, gestures, pictures, and realia. The participants’ examples were not limited to using visual aids and adding the aforementioned teaching methods/strategies, but also included attempts to connect students’ backgrounds with the science content, as can be seen in the quotes listed in Table 18.

Table 18

Accommodation Strategies to Help ELLs in Science Learning

Responses
It will influence how I present subject matter. Obviously, hands-on experiments help these learners, but so do pictures and realia. I’ll need to make real world connections between content and familiar background knowledge to help ELL’s understand concepts and vocabulary.
I will just make sure I use a lot of visuals so all students can follow along. I may even look up the terms in the students' home language if it would help them. Language differences mean that I have to do more examples with more pictures. These can even be short video clips to help them to make these connections between language and life.
A student's language background will greatly affect my science lesson. Their language skills will affect the lesson, because their proficiency level will determine their content and vocab knowledge. This could mean that I would need to spend extra time teaching vocabulary and connecting it to familiar words in the student’s native language, if possible. This would also mean that throughout my lesson I would have to provide necessary accommodations and that I will need to be consistently checking for comprehension. Overall, the experiment would also look different, because I would need to slow down and repeat steps if the students were at a lower proficiency level. However, if the students were at a proficient level then the lesson may be hardly different at all.
Language can be tough sometimes. Some ELLs are not as comfortable in a classroom full of students who have English as their L1. It is my responsibility to give them the necessary differentiation and accommodation to succeed in my class based on the specific child. It is impossible for me to go in depth when I do not have a real-life scenario of a child with XYZ language background, etc.

Although the participants were knowledgeable about how to help ELLs, many were not confident about their ability to teach science to this type of students (see Table 19). They described ELLs’ insufficient English proficiency and its impact on teaching and learning science by using such words as “barrier,” “obstacle,” “challenge,” “difficult,” “hinder,” “tough,” “struggle,” and “fear” (Appendix C). Of those words, “barrier/s” (word count: 35, 0.58%) was the most frequently used. That is, the participants perceived that a “language barrier” could interfere with both the ELLs’ ability to learn and their own effectiveness to teach science.

Table 19

Lack of Confidence in Teaching Science to ELLs

Responses
It can be harder to explain non-concrete ideas to students when there is a language barrier.
ESL students can create a language barrier for me in teaching science because I already struggle at science.
I think I will struggle teaching science to ELL students.
It would be hard to teach someone who doesn't know English.
When my students speak a different language, it would hinder my teaching and make it a little bit more difficult, but I can provide word walls and pictures to demonstrate what I am saying or expecting, etc. so that they would understand and learn a little bit more.

Particularly, the participants pointed out that scientific vocabulary (word count: 62, 1.02%) would be the most challenging factor for both teaching and learning science. As can be seen in Table 20, they characterized scientific vocabulary as “distinct,” “jargon-specific,” and “complicated.” They believed there were some vocabulary items that would be used only in a science context, have different meanings in other fields, or have their roots in foreign languages. This characteristic would make them as future teachers unable to connect the vocabulary items to the students’ real lives or associate the words with their English origins. Accordingly, they believed that ELLs might struggle to grasp the meaning and have difficulties remembering the vocabulary, which could hinder the students’ science learning.

To summarize, the majority of the participants believed that to support equity in ELLs’ science education, teachers should provide appropriate accommodations; this was because students would be unlikely to have sufficient English proficiency. Although the participants demonstrated knowledge about English as a Second Language (ESL) pedagogy, at the same time they showed a lack of confidence in teaching science to those students. In addition, they considered speaking languages other than English to be a barrier for both teaching and learning science.

Table 20

Vocabulary in Science Teaching and Learning for ELLs

Responses
A student's language background will definitely affect the teaching of science, because science is a subject that is usually … taught in English. If that student is not proficient in English, it will make it difficult for the student to learn science in English, especially if [certain] science words are completely distinct from [those] of English science words. This would be a couple steps backwards, because then this would require the re-teaching of those words and concepts.
I do think that ESL students will affect my teaching because science has jargon specific to it and vocabulary that may be difficult for ELLs to understand. Science normally does have very detailed, written out instructions to follow, and if an ELL is not a proficient reader or listener, then their understanding of the lesson can be clouded due to frustration.
Science utilizes complicated terms and these might be difficult for the students if they don't have a broad knowledge of the language.
Because science is so academic language based with a lot of tricky vocabulary, it's important to go big picture in this area. Science is extremely important and needed in our world, but when people become so hung up on vocabulary the meaning and importance is lost. If I am teaching students who lack knowledge in English I want to cater materials to their needs, and weed out detail concepts such as facts and individual names.

Results of the Frequency Analysis

The theme of equity in science education being associated with students' English proficiency was supported by the findings of the frequency analysis that addressed in the participants' responses to the question of how students' language backgrounds might affect their future science teaching. Of the total 6,086 words in the participants' responses, those recurring the most were *help*-related words (e.g., *help/helps/helpful, modify/modified/modification/modifications, support/supports/supporting,* *accommodate/accommodates/accommodated/accommodations*; word count: 183, 3.03%). Following were *need*-related words (e.g., *need/needs/needed, require/requires/requiring;* word count: 105, 1.73%), *barrier*-related words (e.g., *barrier/s, problem/s, challenge/challenged/challenging, difficult/difficulty, hinder, interfere, obstacle, trouble;* word count: 100, 1.67%), *understand*-related words (e.g., *understand/understands/understanding, comprehend/comprehends/comprehending/comprehension/comprehensive*; word count: 82, 1.35%), and *vocabulary*-related words (e.g., *vocabulary, terms, word/s, terminology, jargon*; word count: 62, 1.02%; Appendix C).

CHAPTER 5

DISCUSSION

Introduction

Using a mixed-methods approach, the current study investigated if early childhood preservice teachers' cultural diversity awareness was related to their sense of self-efficacy about equitable science teaching and learning. The study also examined if the participants' race/ethnicity and the number of languages they speak moderated the relationship between their senses of cultural diversity awareness and self-efficacy about equitable science teaching and learning. Furthermore, the analyses identified the preservice teachers' concepts of equity in general and in science education specifically as well as their applications of the equity concepts to future science teaching toward students with diverse backgrounds.

In this chapter, the quantitative results section discusses the findings regarding Research Questions 1 and 2, and the qualitative results section discusses the findings regarding Research Questions 3 and 4. A comparison of the quantitative results with the qualitative results is made to confirm whether the results of both parts are in alignment. The chapter then addresses this study's implications for teacher preparation programs and for teacher educators. Finally, the current study's limitations are acknowledged, and future studies are suggested.

Quantitative Results

After performing EFAs on the CDAI and SEBEST, which were used to measure participants' cultural diversity awareness and self-efficacy in equitable science teaching and learning, the number of items and subscales on the both scales were modified. In particular, the CDAI had the reduced number of items and the subscales, and the subscales were relabeled as

(a) Creating a Multicultural Environment and Instruction (CMEI), (b) Insensitivity and Biases/Lack of Knowledge about Diversity (IBLKD), and (c) Discomfort with Cultural and Linguistic Diversity (DCLD). In regard to the SEBEST, despite the deletion of some items, the subscales of STOE and PSTE were retained because changing the number of subscales caused a conflict with this scale's theoretical foundation. Because the scales were revised based on the results of the EFAs, they may no longer represent the same constructs that the developers targeted. Therefore, the validity of the two instruments had become questionable.

Research Question 1

With the revised scales, multiple regressions were used to identify whether any of the CMEI, IBLKD, and DCLD scores on the CDAI predicted the STOE or PSTE scores on the SEBEST. The analyses found a statistical significance indicating that participants' CMEI and IBLKD scores predicted their STOE scores ($\beta = .308$, $p < .001$; $\beta = .354$, $p < .001$, respectively). In addition, the CMEI, IBLKD, and DCLD scores were positively related to the STOE scores ($r_s = .719$, $r_s = .807$, and $r_s = .411$, respectively). This means that when participants were more aware of creating a multicultural environment and instruction, and/or when they were less biased and more sensitive and knowledgeable about the diversity of students and their families, they had higher expectations about science learning of students from diverse backgrounds.

In terms of the PSTE, the statistically significant results indicated that participants' scores on the CMEI, IBLKD, and DCLD in the CDAI predicted PSTE with a positive direction ($\beta = .180$, $r_s = 550$, $p < .001$; $\beta = .209$, $r_s = .705$, $p < .001$; $\beta = .288$, $r_s = .811$, $p < .001$, respectively). That is, the more aware the participants were of creating a multicultural environment and instruction, the higher their sense of science teaching efficacy. In addition, if they were less biased and were also sensitive and knowledgeable about students' and their families' diverse backgrounds, they were more likely to have a strong sense of efficacy in teaching science to such students. Finally, when the participants felt more comfortable about confronting students or parents whose cultures and languages were different from their own, they tended to have a stronger sense of science teaching efficacy. Given the challenges with the validity of the two instruments, these results should be treated with caution, and the findings are considered to be inconclusive.

Research Question 2

Analyses found that participants' race/ethnicity moderated the relationship between the CMEI scores and the STOE scores, with a statistical significance of $\Delta R^2 = .01$, $F(1, 345) = 5.485$, $p < .05$, meaning that the effect of the CMEI scores on predicting the STOE scores differed, depending on participants' race/ethnicity. The results showed that awareness of creating a multicultural environment and instruction was associated with increases in science teaching outcome expectancy for both White and non-White participants; however, that awareness had a stronger effect on the White participants (i.e., higher STOE scores) than the non-White participants.

Also, the analyses found a statistical significance in the number of languages the participants speak in association with their science teaching efficacy with a positive direction ($\beta = .181$, $r_s = .353$, $p < .001$). This implies that, compared with monolingual participants, multilingual participants were likely to have a stronger sense of science teaching efficacy regarding students from diverse backgrounds. Hwang and Vrongistinos (2004) found similar results when they conducted research on the effect of teachers' language on their teaching efficacy. Although their study did not focus on science education, they found that immigrant teachers had a strong sense of efficacy in teaching students with limited English proficiency and believed that they could have a positive impact on learning for those students.

Not much research has focused on exploring how perspectives on diversity are associated with self-efficacy as it relates to equity in science education. Similarly, how preservice/inservice teachers' demographic profile moderates the relationship between their cultural awareness and self-efficacy in equitable science teaching and learning has not been much explored. For this reason, the findings of the current study could contribute to the body of literature on early childhood science education as well as that of multicultural education. At the same time, these findings could help provide a starting point for other researchers to expand or replicate this study; doing so could reinforce the validity of the current findings. As stated before, a major challenge in this study has been the validity of the instruments used, thus, these results should be considered with caution. However, the issues are relevant and deserve further examination.

Qualitative Results

Research Question 3

Regarding the qualitative findings, the participants held alternative concepts about equity in science education. One third of the participants understood equity as providing appropriate access and support based on the levels of students' needs. However, another one third defined equity as providing identical teaching services and resources to all students regardless of their backgrounds.

Although the definitions about equity from the remaining third of the participants did not develop as a theme, their definitions should be clarified. The definitions belonged neither to the “identical teaching services and resources” group nor to the “appropriate access and support” group. The participants described equity as something else (e.g., adding values) or failed to articulate it (e.g., I am not sure at this time/I don’t know). Along with those who defined equity as equality did not understand what equity is, these participants did not grasp the meaning of equity. Therefore, it can be concluded that only one third of the participants demonstrated an understanding of equity in general and in science education. This finding aligned with the literature demonstrating that many preservice teachers had an unclear understanding of equity (Gayle-Evans & Michael, 2006; Gollnick & Chinn, 2015).

Research Question 4

Almost all participants acknowledged that, as future teachers, equity in science education was the most relevant to students whose English proficiency was insufficient. While advocating equity for those students, they provided various methods of helping and supporting ELLs during science teaching. It can be inferred that the participants’ awareness and pedagogical knowledge about linguistic diversity became stronger through ongoing lesson plan design practices, as teacher education has emphasized.

Teacher preparation programs have trained preservice teachers for designing lesson plans and conducting microteaching based on the lessons. Although preservice teachers are mostly asked to design a lesson geared toward “one group,” they were asked to add accommodations/modifications to the end of the lesson plan for “pre-selected student groups.” Most of the time, these “pre-selected student groups” referred to students with insufficient English proficiency and/or students with special needs. These practices may have heightened these preservice teachers’ linguistic diversity awareness. As supporting evidence, most participants listed several ways to support ELLs to learn science but listed only one or none for students in other diversity categories.

On the contrary, most of the participants excluded students of various racial/ethnic backgrounds from their list of promoting equity in science education. Some participants who expressed this belief attributed it to the universality of science, as evidenced by the literature (Cobern & Loving, 2001; Lee & Buxton, 2008; Lee & Luykx, 2007); thus, for them, accommodating students of different racial or ethnic backgrounds would be unnecessary. Additionally, most of the participants adopted a colorblind approach/policy. The participants explained that they would not adapt science teaching for students with diverse racial/ethnic backgrounds because they did not see students' color or did not believe that race/ethnicity affects learning. The finding is consistent with previous studies that colorblindness or color-denial is a prevalent perspective among preservice and inservice teachers with respect to working with diverse students and their families (Hachfeld et al., 2015; Kreamelmeyer, Kline, Zygmunt, & Clark, 2016; Walker, 2011; Zygmunt-Fillwalk, 2005).

Colorblindness centers on equal opportunities without acknowledging potential differences among student backgrounds (Southerland et al., 2011). Fryberg (2010) argued that masking with the colorblind ideology helps teachers feel safe and avoid situations in which they could be labeled potential racists, although internally they preserve the current social order and White privilege that society takes for granted. In this light, Bonilla-Silva (2009) defined colorblindness as a *new racism* that ultimately damages learning for students with racial/ethnic diversity by using a positive image of an *advocate of equality*.

Wise (2010) further explained this potential *damage* in his book *Color Blind: The Rise of Post-Racial Politics and the Retreat from Racial Equity*. According to him, teachers espousing a colorblind ideology certainly underserve students' needs and do not evaluate whether their curricula are in alignment with multicultural education. Hachfeld et al. (2015) supported these researchers' claims by juxtaposing colorblind beliefs opposite to multicultural beliefs. Their findings demonstrated that teachers who had colorblind beliefs were less willing to modify their instruction for immigrant students. On the other hand, those who had multicultural beliefs had strong self-efficacy and enthusiasm for teaching those students. Also, they were more willing to modify their instruction and were less stereotyped about the academic motivation of these students and their families' support.

These characteristics of adopted colorblindness were in line with the findings from the participants' responses. Participants who took the colorblind perspective distanced themselves from involvement in race-related issues. They also revealed their concerns about teaching students with racial/ethnic diversity by using such words as "discrimination" and "favoritism/preference"; therefore, they would not change science teaching in terms of various students' race/ethnicity because they did not want others to label them as racists.

Alignment between the Qualitative Results and Quantitative Results

The qualitative results made evident that the participants were strongly aware of linguistic diversity but not racial/ethnic diversity; accordingly, the participants failed to provide appropriate access and support to students regarding racial/ethical diversity in science learning but did provide adequate accommodation methods for students with linguistic diversity. This pattern in the qualitative findings aligned with a general idea of the quantitative findings; that is, the participants' cultural diversity awareness was positively associated with their self-efficacy in equitable science teaching and learning.

Bandura (1986, 1997) asserted that self-efficacy beliefs influence human behavior. Applying his claim to the current research context, self-efficacy could be regarded as an indicator of how the participants planned to teach science to students with diverse backgrounds. Therefore, participants who were highly self-efficacious in equitable science teaching and learning, they would be more likely to put more effort toward promoting equity in science learning for students with diverse backgrounds by providing appropriate instructional accommodations. In this manner, the qualitative study results were in line with those of the quantitative study.

Conclusion and Implications

This study's findings have critical implications for teacher education because these participants were about to commence their student teaching after completing science methods courses. As the qualitative results show, the majority of the participants were not aware of how students' race/ethnicity affected their science learning and also could not provide accommodation methods for these students. This implies that they would be less likely to provide equitable science teaching to such students in the future. In particular, the colorblindness pervasive among the participants could become problematic. Based on their own justification that they did not see students' color or that students' color did not affect science learning, they might not attempt to support students of racial/ethnic diversity in science learning.

A study participant stated in one of the open-ended questions that "students' racial/ethnic background has not affected my science teacher or any science teaching I have observed." Along with this testimony, the findings of the study point out that teacher education may not be adequately equipping early childhood preservice teachers to teach science to diverse student populations. Based on this study findings, it seems like neither multicultural education courses nor other courses were effective in developing sensitivity and responsiveness to student diversity among preservice teachers.

As testified by the participant above, teacher educators may not be aware of the preservice teachers' diversity, so while considering preservice teachers as a mono-cultural group (Irvine, 2003), they might have provided "one-size-fits-all" instruction for teaching all preservice teachers (Roehrig & Luft, 2006); they might not have been exemplary models for advocating for the educational equity of preservice teachers with diverse backgrounds. Moreover, they may not have emphasized diverse cultures, races/ethnicities, or socioeconomic statuses as much as they emphasized linguistic diversity, which resulted in the preservice teachers' unbalanced awareness. As a consequence, the values and instructional practices of these teacher educators may possibly have been transferred to the preservice teachers. Therefore, it is suggested that teacher educators should identify their own cultures and values, and they should examine their biases and prejudices toward other cultures (i.e., preservice teachers' cultures) (García & Guerra, 2004). After acknowledging, understanding, and valuing their own and other cultures, they should find ways to integrate this cultural information into their teaching practices. Furthermore, they should be intentional in providing preservice teachers with the knowledge and skills required to effectively educate diverse students.

The current research findings demonstrated that there might be a positive association between cultural diversity awareness and self-efficacy in equitable science teaching and learning. They also showed that increasing cultural diversity awareness might be more effective in enhancing White participants' self-efficacy. Taking these findings as well as racial/ethnic composition of teacher preparation programs into consideration, it seems that teacher educators should develop more concrete and active plans in order to promote cultural diversity awareness among early childhood preservice teachers.

Regarding how early childhood preservice teachers could become culturally aware and advocate equity in science education for young diverse learners, this study provides several suggestions. First, teacher educators may create opportunities for preservice teachers to identify their own cultures as well as to critically and continuously reflect on their own biases and prejudices toward others' cultures (García & Guerra, 2004). For example, when designing courses, they may, on a regular basis, schedule explicit discussions about issues related to equity and diversity based on class reading materials related to cultural diversity (Cones, 2009a). This method will be helpful for enhancing preservice teachers' self-awareness as well as awareness about other cultures. In addition, teacher educators should serve as role models in providing equitable learning opportunities to preservice teachers with diverse backgrounds. For example, they should build classroom activities related to course content that are grounded in real-world examples and students' authentic experiences. In this manner, all the classes offered in teacher education programs could become a desirable model for bridging the gap between theory and practice (Ellerbrock & Cruz, 2014).

Reshaping early childhood preservice teachers' firmly rooted beliefs or attitudes, developed throughout their lives, is challenging. However, as many empirical studies—including the current study—have shown, helping preservice teachers become culturally sensitive and responsive plays an important role in equitably serving young, diverse learners in science education. It also ultimately affects these young diverse learners' success in science learning. Therefore, rather than presenting sporadic or isolated experiences, teacher educators should put their efforts into providing ongoing and context-related experiences to promote preservice teachers' cultural diversity awareness.

Limitation and Recommendations

This study has a major limitation in terms of the quality of the two instruments used to measure preservice teachers' cultural diversity awareness (CDAI) and Self-Efficacy Beliefs in Equitable Science Teaching and Learning (SEBEST). Because these two instruments were developed based on a conceptual or theoretical framework, CFAs had to be run to verify factor structures of a set of items. However, when the developers' suggestions were followed, the CFA failed to verify the factor structures of the two instruments. For this reason, instead of using the CFA method, an EFA was utilized, and the two instruments' items and the factors were rearranged based on the results of the eigenvalue-greater-than-one rule, scree plot, the MAP test, and PA.

Unfortunately, many studies have been conducted and published using either the CDAI (e.g., Brown, 2004a, 2004b; Iwai, 2013; Larke, 1990; Majzub et al., 2011, Milner et al., 2003; Russell & Russell, 2014; Wang, Castro, & Cunningham, 2014) or the SEBEST (e.g., Cone, 2009a, 2009b; Settlage, Southerland, Smith, & Ceglie, 2009) without testing the validity of the instruments. Consequently, a recommendation that emerged from this study is that further research is needed to improve the quality of these two instruments by examining their content and construct validity. Alternatively, new instruments could be developed to measure the constructs of cultural awareness and self-efficacy about equitable science education. These are critical areas in the field of education given the increasing diversity in the student population in the United States and elsewhere.

APPENDIX A

DEMOGRAPHICS QUESTIONNAIRE

Background Information

1. EUID: ____________________ Student Number: __________________

2. Gender: _______ Male _______ Female

3. Age:

_____ 18 – 21

_____ 22 – 24

_____ 25 – 28

_____ 29 +

4. Ethnicity/Race:

_____ African/African American

_____ Asian/Pacific Islander

_____ Caucasian

_____ Latino/Hispanics

_____ American Indian

_____ Multi Races

_____ Other

5. Language: _____ Monolingual _____ Bilingual _____ More than two

APPENDIX B

OPEN-ENDED QUESTIONS

Open-Ended Questions

The purpose of this short answer is to understand your beliefs about teaching science. There are no right or wrong answers to the following questions or statements. The answers from all the people responded will be combined for a research study. Nothing you say will ever be identified with you personally.

1. How, if at all, will your students' racial/ethnic backgrounds affect your science teaching?

2. How, if at all, will your students' social class backgrounds affect your science teaching?

3. How, if at all, will your students' language backgrounds affect your science teaching?

4. How, if at all, will your students' cultural backgrounds affect your science teaching?

5. How would you define equity?

6. What do you think equity means when teaching science?

APPENDIX C

FREQUENCY ANALYSIS TABLES

Table C.1

Frequency Analysis of the Definitions of Equity in General (A Total of Words Found: 3943)

Word	Frequency	Percentage
Equity	120	3.04%
Equitable	4	0.10%
Unbiased	2	0.05%
Fair	72	1.83%
Fairness	16	0.41%
Fairly	6	0.15%
Impartial	10	0.25%
Justice	2	0.05%
Total	232	5.88%
Word	Frequency	Percentage
Equal	92	2.33%
Equality	24	0.61%
Equally	13	0.33%
Same	90	2.28%
Equals	2	0.05%
Total	221	5.61%
Word	Frequency	Percentage
Need	51	1.29%
Needs	12	0.30%
Require	2	0.05%
Requires	1	0.03%
Necessary	9	0.23%
Necessarily	1	0.03%
Necessity	1	0.03%
Total	77	1.95%
Word	Frequency	Percentage
Opportunity	38	0.96%
Opportunities	16	0.41%
Chance	10	0.25%
Chances	2	0.05%
Total	66	1.67%
Word	Frequency	Percentage
Treating	26	0.66%
Treated	12	0.30%

Treat	11	0.28%
Treatment	11	0.28%
Total	60	1.52%
Word	Frequency	Percentage
Help	18	0.46%
Assistance	3	0.08%
Aid	2	0.05%
Supporting	1	0.03%
Helping	1	0.03%
Support	8	0.20%
Scaffolding	1	0.03%
Boost	1	0.03%
Accommodations	7	0.18%
Accommodating	3	0.08%
Accommodated	1	0.03%
Modifications	5	0.13%
Adaptations	2	0.05%
Adjust	1	0.03%
Adjustments	1	0.03%
Adaptation	1	0.03%
Alter	1	0.03%
Modifying	1	0.03%
Differentiation	1	0.03%
Total	59	1.49%

Table C.2

Frequency Analysis of the Definitions of Equity in Science Education (A Total of Words Found: 4703)

Word	Frequency	Percentage
Equal	47	1.00%
Equality	1	0.02%
Equally	12	0.26%
Equals	2	0.04%
Same	75	1.60%
Total	137	2.91%
Word	Frequency	Percentage
Differentiated	1	0.02%
Differentiation	3	0.06%

Differentiating	2	0.04%
Modifications	9	0.19%
Modifying	4	0.09%
Adaptations	3	0.06%
Modify	2	0.04%
Adjust	2	0.04%
Alter	2	0.04%
Altered	1	0.02%
Adjusting	1	0.02%
Adaptation	1	0.02%
Adapting	1	0.02%
Adaptions	1	0.02%
Changes	1	0.02%
Accommodations	17	0.36%
Accommodating	5	0.11%
Accommodate	4	0.09%
Help	24	0.51%
Assistance	5	0.11%
Helping	4	0.09%
Helped	1	0.02%
Supports	3	0.06%
Support	3	0.06%
Supporting	2	0.04%
Scaffold	1	0.02%
Scaffolding	4	0.09%
Total	107	2.27%
Word	Frequency	Percentage
Need	47	1.00%
Needs	25	0.53%
Needed	11	0.23%
Require	5	0.11%
Necessary	4	0.09%
Required	1	0.02%
Requires	1	0.02%
Necessarily	1	0.02%
Total	95	2.02%
Word	Frequency	Percentage
Equity	54	1.15%
Fair	27	0.57%

Fairness	4	0.09%
Fairly	3	0.06%
Equitable	2	0.04%
Impartial	2	0.04%
Equitably	1	0.02%
Nonbiased	1	0.02%
Total	94	2.00%

Table C.3

Frequency Analysis of Responses to the Impact of Students' Language Backgrounds on Science Teaching (A Total of Words Found: 6086)

Word	Frequency	Percentage
Accommodations	20	0.34%
Accommodate	9	0.15%
Accommodation	4	0.07%
Accommodated	1	0.02%
Accommodates	1	0.02%
Modifications	23	0.38%
Modify	13	0.21%
Modified	3	0.05%
Modification	2	0.03%
Adapt	6	0.10%
Adapted	1	0.02%
Adaptations	4	0.07%
Adaptions	3	0.05%
Change	6	0.10%
Adjustments	2	0.03%
Alter	2	0.03%
Tailor	2	0.03%
Differentiated	3	0.05%
Differentiate	2	0.03%
Differentiating	1	0.02%
Differentiation	1	0.02%
Help	51	0.84%
Helpful	1	0.02%
Helps	1	0.02%
Beneficial	2	0.03%
Benefit	2	0.03%
Aid	3	0.05%
Aids	3	0.05%
Aide	1	0.02%
Support	4	0.07%
Supports	3	0.05%

Supporting	1	0.02%
Scaffold	2	0.03%
Total	183	3.03%
Word	Frequency	Percentage
Need	70	1.15%
Needed	10	0.16%
Needs	9	0.15%
Necessary	7	0.12%
Require	7	0.12%
Requires	1	0.02%
Requiring	1	0.02%
Total	105	1.73%
Word	Frequency	Percentage
Barrier	20	0.33%
Barriers	15	0.25%
Obstacle	1	0.02%
Difficult	20	0.33%
Problems	1	0.02%
Problem	2	0.03%
Difficulty	1	0.02%
Trouble	5	0.08%
Challenge	4	0.07%
Challenging	4	0.07%
Challenged	1	0.02%
Tough	2	0.03%
Fear	2	0.03%
Hard	8	0.13%
Harder	7	0.12%
Hinder	6	0.10%
Interfere	1	0.02%
Total	100	1.67%
Word	Frequency	Percentage
Understand	51	0.84%
Understanding	18	0.30%
Understands	2	0.03%
Comprehensible	3	0.05%
Comprehend	2	0.03%
Comprehension	2	0.03%
Comprehensive	2	0.03%
Comprehending	1	0.02%
Comprehends	1	0.02%
Total	82	1.35%

Word	Frequency	Percentage
Vocabulary	27	0.45%
Jargon	1	0.02%
Terms	18	0.30%
Word	2	0.03%
Terminology	2	0.03%
Words	12	0.20%
Total	62	1.02%

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